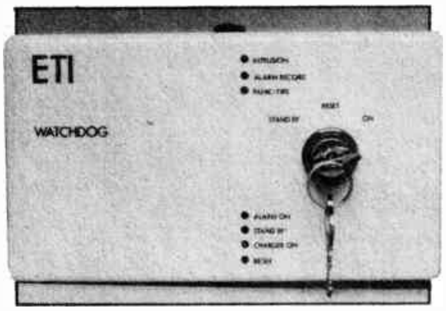
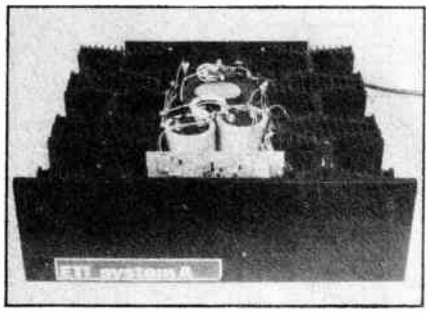
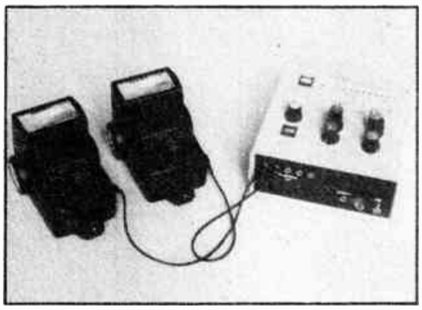
Disc discussion p.47



Burglars beware p.18



Class A quality p.40



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AUGUST 1981 VOL 10 NO 8

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Have you heard about CB? Citizens' Band radio is to be legalised this Autumn; yes, that's right, our very own personal two-way radio system that can be used in the car, the home — anywhere. As you can imagine, CB will be a real boon to the motorist, the housebound, those who go for outdoor activities — and don't forget that CB can save lives!

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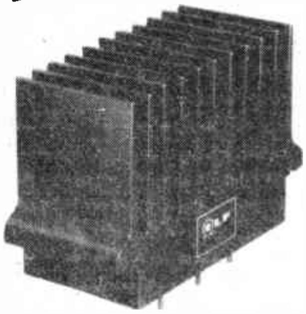
Which amplifier?

I.L.P. Amplifiers now come in three basic types, each of which is available with or without heatsink. Having decided the system you want – home hi-fi (models HY30, 60 or 120 for example), super quality hi-fi with extra versatility (MOS120, MOS200) or Disco/PA/Guitar (HD120, HD200 or HD400) you will then decide whether amplifiers housed within their own heatsinks or plate amplifiers for bolting to a metal chassis will suit. With choice such as this and a brilliant new range of I.L.P. functional modules to choose from you now have the chance to build the finest audio system ever offered to the constructor.



AMPLIFIER WITH HEAT SINK

BIPOLAR Standard, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	DISTORTION T.H.D. Typ at 1kHz	DISTORTION I.M.D. 60HZ/7kHz 4:1	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HY30	15w/4-8Ω	0.015%	<0.006%	±18±20	76x68x40	240	£7.29	£1.09					
HY60	30w/4-8Ω	0.015%	<0.006%	±25±30	76x68x40	240	£8.33	£1.25					
HY120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x40	410	£17.48	£2.62	HY120P	120x26x40	215	£15.50	£2.33
HY200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x50	515	£21.21	£3.18	HY200P	120x26x40	215	£18.46	£2.77
HY400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£31.83	£4.77	HY400P	120x26x70	375	£28.33	£4.25

Protection: Load line, momentary short circuit (typically 10 sec) *Slew rate:* 15V/μs *Rise time:* 5μs
S/N ratio: 100db *Frequency response (– 3dB):* 15Hz – 50kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

HEAVY DUTY with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
HD120	60w/4-8Ω	0.01%	<0.006%	±35±40	120x78x50	515	£22.48	£3.37	HD120P	120x26x50	265	£19.84	£2.98
HD200	120w/4-8Ω	0.01%	<0.006%	±45±50	120x78x60	620	£27.38	£4.11	HD200P	120x26x50	265	£23.63	£3.54
HD400	240w/4Ω	0.01%	<0.006%	±45±50	120x78x100	1025	£38.63	£5.79	HD400P	120x26x70	375	£34.28	£5.14

Protection: load line, PERMANENT SHORT CIRCUIT (ideal for disco/group use should evidence of short circuit not be immediately apparent).
The Heavy Duty range can claim additional output power devices and complementary protection circuitry with performance specs. as for standard types.

PLATE TYPE

MOSFET Ultra-Fi, with heatsinks / Without heatsinks

MODEL NUMBER	OUTPUT POWER Watts rms	T.H.D.	I.M.D.	SUPPLY VOLTAGE TYP/MAX	SIZE mm	WT gms	PRICE	VAT	MODEL NUMBER	SIZE in mm	WT gms	PRICE	VAT
MOS120	60w/4-8Ω	<0.005%	<0.006%	±45±50	120x78x40	420	£25.88	£3.88	MOS120P	120x26x40	215	£23.32	£3.50
MOS200	120w/4-8Ω	<0.005%	<0.006%	±55±60	120x78x80	850	£33.46	£5.02	MOS200P	120x26x80	420	£28.53	£4.28
MOS400	240w/4Ω	<0.005%	<0.006%	±55±60	120x78x100	1025	£45.39	£6.81	MOS400P	120x26x100	525	£38.91	£5.84

Protection: Able to cope with complex loads, without the need for very special protection circuitry (fuses will suffice).
Ultra-fi specifications:
Slew rate: 20V/μs *Rise time:* 3μs *S/N ratio:* 100db *Frequency response (– 3dB):* 15Hz – 100kHz
Input sensitivity: 500mV rms *Input impedance:* 100kΩ *Damping factor:* (8Ω/100Hz)>400

POWER SUPPLY UNITS

MODEL NO.	FOR USE WITH	PRICE	VAT
PSU30	± 15V combinations of HY6/66 series to a maximum of 100mA or *one* HY67. The following will also drive the HY6/66 series except HY67 which requires the PSU30.	£4.50	£0.68
PSU36	1 or 2 HY30	£8.10	£1.22
PSU50	1 or 2 HY60	£10.94	£1.64
PSU60	1 x HY120/HY120P/HD120/HD120P	£13.04	£1.96
PSU65	1 x MOS120/1 x MOS120P	£13.32	£2.00
PSU70	1 or 2 HY120/HY120P/HD120/HD120P	£15.92	£2.39
PSU75	1 or 2 MOS120/MOS120P	£16.20	£2.43
PSU90	1 x HY200/HY200P/HD200/HD200P	£16.20	£2.43
PSU95	1 x MOS200/MOS200P	£16.32	£2.45
PSU180	2 x HY200/HY200P/HD200/HD200P or 1 x HY400/1 x HY400P/HD400/HD400P	£21.34	£3.20
PSU185	1 or 2 MOS200/MOS200P/1 x MOS400/ 1 x MOS400P	£21.46	£3.22

All models except PSU30 and PSU36 incorporate our own toroidal transformers.

PSU

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Ω I.L.P

Which modules?

In launching eighteen different units all within amazingly compact cases to help make complete audio systems using I.L.P. power amplifiers, we bring the most exciting, the most versatile modular assembly scheme ever for constructors of all ages and experience. Study the list – see how these modules will combine to almost any audio project you fancy – and remember *all I.L.P. modules are compatible with each other*, they connect easily. Modules HY6 to HY13 measure 45 x 20 x 40mm. HY66 to HY77 measure 90 x 20 x 40mm. They are so reliable that all I.L.P. modules carry a 5 year no quibble guarantee.

MODEL NO.	MODULE	DESCRIPTION/FACILITIES	CURRENT REQUIRED	PRICE	VAT
HY6	MONO PRE AMP	Mic/Mag. Cartridge/Tuner/Tape/ Aux + Volume/Bass/Treble	10mA	£6.44	£0.97
HY7	MONO MIXER	To mix eight signals into one	10mA	£5.15	£0.77
HY8	STEREO MIXER	Two channels, each mixing five signals into one	10mA	£6.25	£0.94
HY9	STEREO PRE AMP	Two channels mag. Cartridge/ Mic + Volume	10mA	£6.70	£1.01
HY11	MONO MIXER	To mix five signals into one + Bass/Treble controls	10mA	£7.05	£1.06
*HY12	MONO PRE AMP	To mix two signals into one + Bass/Mid-range/Treble	10mA	£6.70	£1.01
*HY13	MONO VU METER	Programmable gain/LED overload driver	10mA	£5.95	£0.89
HY66	STEREO PRE AMP	Mic/Mag. Cartridge/Tape/Tuner/Aux + Volume/Bass/Treble/Balance	20mA	£12.19	£1.83
HY67	STEREO HEADPHONE	Will drive headphones in the range of 4Ω – 2KΩ	80mA	£12.35	£1.85
HY68	STEREO MIXER	Two channels, each mixing ten signals into one	20mA	£7.95	£1.19
HY69	MONO PRE AMP	Two input channels of mag. Cartridge/ Mic + Mixing/Volume/Treble/Bass	20mA	£10.45	£1.57
HY71	DUAL STEREO PRE AMP	Four channels of mag. Cartridge/Mic + Volume	20mA	£10.75	£1.61
*HY72	VOICE OPERATED STEREO FADER	Depth/Delay	20mA	*To be announced*	
*HY73	GUITAR PRE AMP	Two Guitar (Bass/Lead) and Mic + separate Volume/Bass/Treble + Mix	20mA	£12.25	£1.84
†HY74	STEREO MIXER	Two channels, each mixing five signals into one + Treble/Bass	20mA	£11.45	£1.72
†HY75	STEREO PRE AMP	Two channels, each mixing two signals into one + Bass/Mid-range/Treble	20mA	£10.75	£1.61
†HY76	STEREO SWITCH MATRIX	Two channels, each switching one of four signals into one	20mA	*To be announced*	
†HY77	STEREO VU METER DRIVER	Programmable gain/LED overload driver	20mA	£9.25	£1.39

* Ready August – may be ordered now
† Ready September – may be ordered now

All the above modules operate from ±15V minimum to ±30V maximum – higher voltages being accommodated by use of dropper resistors. HY67 can only be used with the PSU 30 power supply unit.

The modules are encapsulated and include latest design high quality clip-on edge connectors.

For easy mounting we recommend
B6 Mounting board for modules HY6 – HY13
78p + 12p. V.A.T.
B66 Mounting board for HY66 – HY77
99p + 13p. V.A.T.

All I.L.P. modules include full connection data.

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HOW IT WORKS

The circuitry of the main unit can be broken down into two distinct sections, with the basic alarm circuitry plus alarm recorder to the right of key switch SW1a, and the burglary-detection circuitry to the left. The circuitry to the right of SW1a is permanently enabled and can be activated at any time by the panic and fire inputs: the burglary-detection circuitry is active only when the system is turned fully on by SW1.

The operation of the basic alarm circuitry and the alarm recorder is fairly simple. IC2a-IC2b is a long-period monostable (several minutes) and can be triggered by applying a high (logic 1) signal to R13 via the D2-D3 OR gate; the mono can thus be triggered by closing any of the fire-detecting thermostats or the panic buttons, or by a high output from IC1d. When the mono is triggered, the output of IC2b goes high for the duration of the monostable period and thus drives RLA (and the external alarm) on via Q1 for a preset period. Simultaneously, the output of IC2a goes low and causes special-purpose bistable IC2c-IC2d to self-latch into a state in which the output of IC2d goes low, driving LED6 (the visual alarm recorder) on and activating the IC3-IC4 audible alarm recorder circuitry. When the monostable turns off at the end of its timed period the external alarm also turns off, but the audio-visual alarm recorder remains active, giving a permanent indication that an alarm action has occurred. The monostable and the recorder can both be reset by briefly moving SW1 to the reset position.

The audible alarm recorder circuitry is quite simple. IC3a-IC3b form a low-frequency astable, which is gated on by a low input signal. IC3c-IC3d form a high-frequency astable (a couple of kilohertz) which is gated by the output of IC3b. The output of the high-frequency astable is fed to acoustic transducer TX1 via bridge-configured driver IC4. Thus, when the circuitry is activated by a low input signal, an audible pulsed-tone signal is generated by TX1.

The burglary-detection circuitry is designed around IC1 and is active only when SW1 is switched to the on position. Here, the N.O. and N.C. burglar-detecting security switches are wired in such a way that a high voltage is normally applied to R3, but this voltage goes low if any of the N.C. switches are opened or the N.O. switches are closed. The R3 voltage is inverted by both IC1a and IC1b, so that LED2 turns on and a high voltage is fed to one input of IC1c if an intrusion occurs; C1 and R5-C2 filter the signals from R3, to eliminate the effects of lightning-induced signals and transients. The other input of IC1c is controlled by the C3-R7 time-controlled network, which causes IC1c to be effectively disabled for a minute or so after SW1 is first moved to the on position or after the optional re-entry switch is momentarily closed. The output of IC1c is inverted by IC1d and fed to the D2 input of the D2-D3 OR gate, where it can control the action of the main alarm circuitry.

Thus, when the burglar alarm circuit is first switched on by SW1 the IC1a-IC1b section is fully enabled, so that LED2 will turn on if any of the security switches are incorrectly set, but IC1c-IC1d are disabled by the C3-R7 network, so that the main alarm will not activate under this condition. After a minute or so, however, the IC1c-IC1d section becomes fully enabled, so the main alarm will sound instantly if any subsequent intrusion is detected.

Note that the main Watchdog unit is powered by a single PP9-style Ni-Cd battery, which is intended to be permanently trickle-charged by an external mains-powered charger circuit. Also note that the circuit is provided with a total of seven LEDs, which give visual indications of the existing operating mode, the presence of sensor faults/actions, the presence of the charger current, and the record of an alarm action.

The charger circuit is very simple and is intended to apply a permanent trickle-charge current of roughly 70 mA to the Ni-Cd battery of the main Watchdog unit. Here, the mains voltage is stepped down, full wave rectified and smoothed by T1-D9-D10-C8, to provide roughly 13 V DC across C8. This voltage is used to power the constant-current generator that is designed around ZD1-R26-Q2-R27. ZD1 sets a standing voltage across emitter resistor R27, which thus determines the emitter current of Q2: since the emitter and collector currents of an active transistor are virtually identical, the collector of Q2 effectively acts as a constant-current source and is used to feed a trickle-charge current to the Watchdog Ni-Cd via D8. LED7 (in the main unit) illuminates when the charger is active.

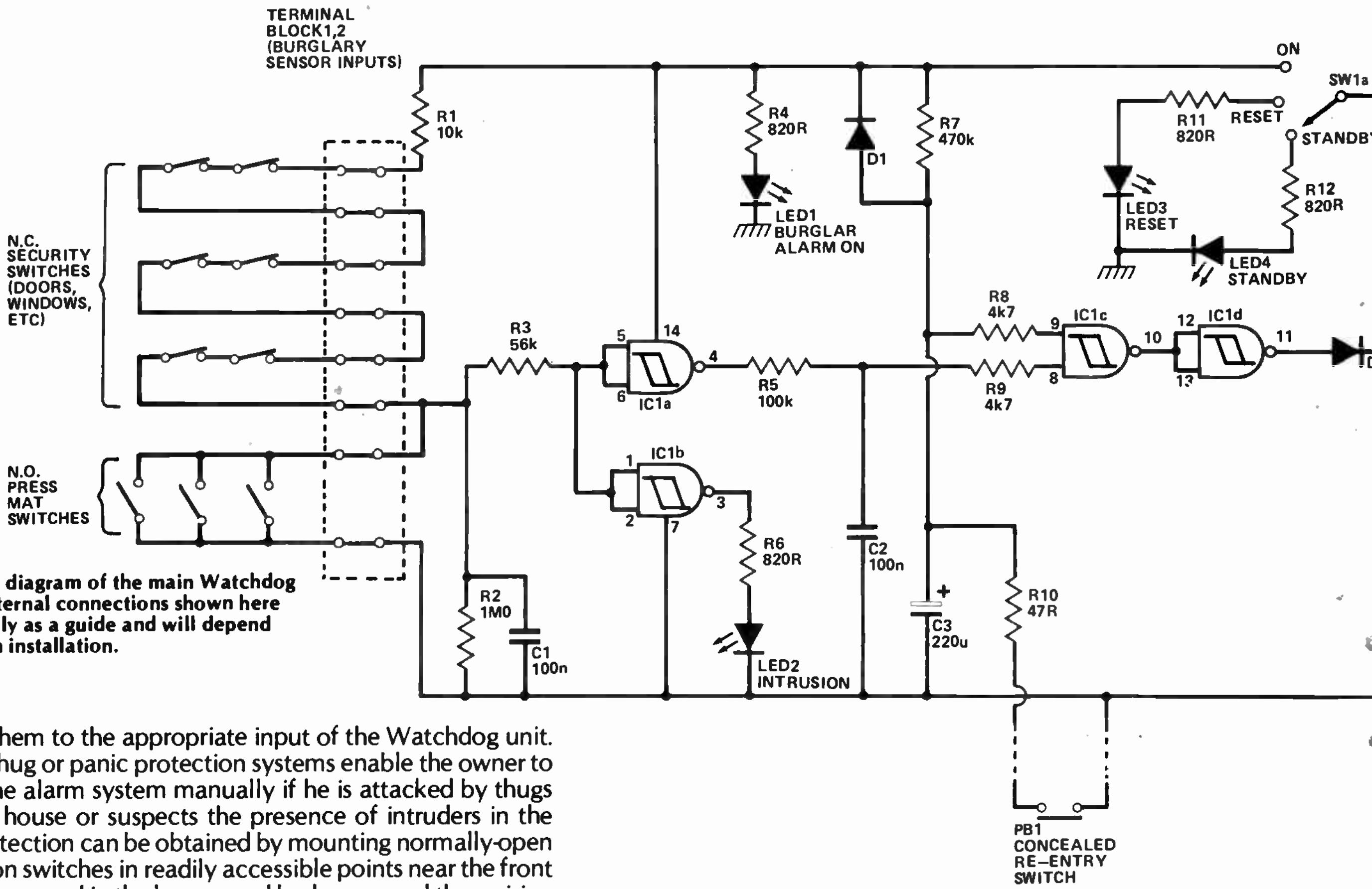


Fig.1 Circuit diagram of the main Watchdog unit. The external connections shown here are given only as a guide and will depend on your own installation.

coupling them to the appropriate input of the Watchdog unit.

Anti-thug or panic protection systems enable the owner to activate the alarm system manually if he is attacked by thugs inside the house or suspects the presence of intruders in the house. Protection can be obtained by mounting normally-open push-button switches in readily accessible points near the front and rear doors and in the lounge and bedrooms and then wiring all of the switches in parallel and coupling them to the Watchdog unit.

BUYLINES

The piezo-electric transducer can be obtained from Ambit International. Electrovalue are stockists for the PCB terminal blocks. The 6 V relay, DC socket and key-switch are available from Watford Electronics.

All the other semiconductor devices used in this project should be available from advertisers in this issue eg Technomatic, Greenweld etc. The Samos 002 case can be obtained from West Hyde Developments.

Special-purpose security sensors, panic buttons and alarms are available from specialist security companies such as Strathand Security, 44 St Andrew's Square, Glasgow G1 5PL.

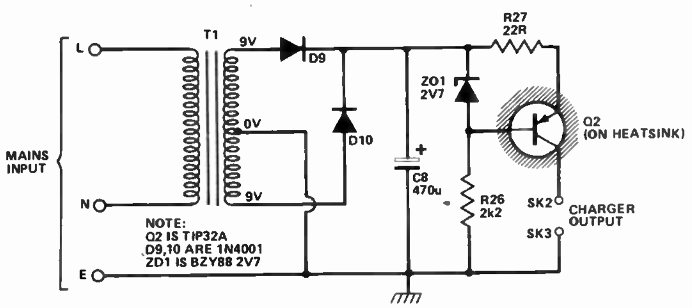


Fig.2 (Above) Circuit diagram of the trickle-charger.

Burglary protection can be obtained either by using a perimeter defence' system that detects the intruder as soon as he enters the building through a protected door or window, or by using a 'spot defence' system that detects him only after entry has been made (as he opens internal doors or treads on concealed pressure mats), or by using a combination of the two systems.

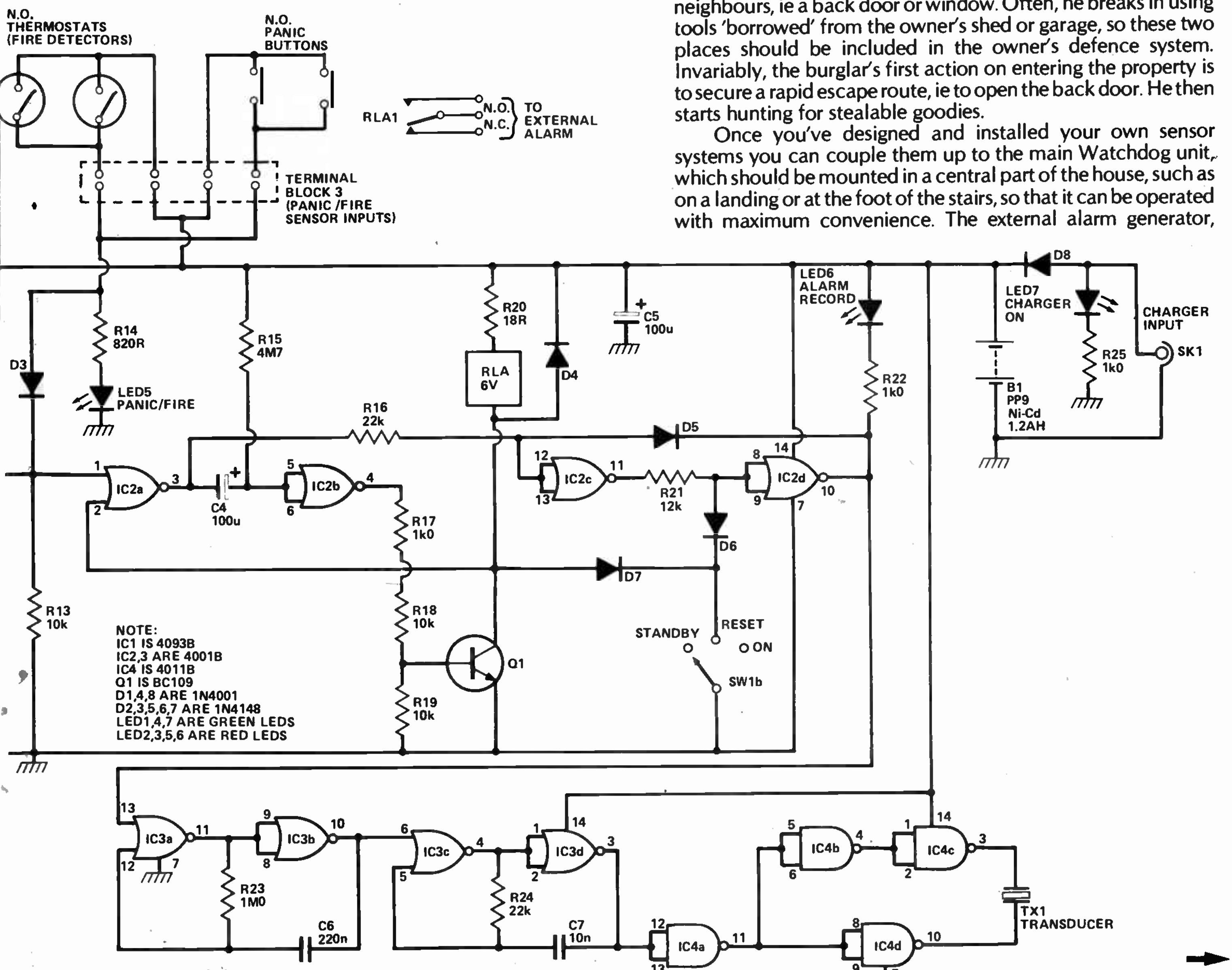
Selected doors and windows are easily protected with a reed-relay/magnet combination: the magnet is installed in the door or the opening window, opposite a reed-relay installed in the frame, so that the relay is normally closed but opens when the door/window is opened. All the relays are then wired in series and connected to the appropriate input of the Watchdog unit, so that the alarm activates when any of the protected doors/windows are opened.

Pressure mats come in a variety of sizes and are easily hidden under rugs and carpets. They are usually normally-open devices, so any number can be wired in parallel and fed to the appropriate input of Watchdog.

Modus Operandi

When planning the installation, the house-owner must try to think like a burglar. Normally, the burglar enters a house from an easy access point that is obscured from the view of the neighbours, ie a back door or window. Often, he breaks in using tools 'borrowed' from the owner's shed or garage, so these two places should be included in the owner's defence system. Invariably, the burglar's first action on entering the property is to secure a rapid escape route, ie to open the back door. He then starts hunting for stealable goodies.

Once you've designed and installed your own sensor systems you can couple them up to the main Watchdog unit, which should be mounted in a central part of the house, such as on a landing or at the foot of the stairs, so that it can be operated with maximum convenience. The external alarm generator,



complete with its own power supply arrangement, can then be coupled to the output of the unit so that it activates when relay RLA closes.

If you decide to mount a re-entry switch on the front door of the house (so that you can enter the building without activating the alarm), take care to conceal its wiring. If required, a number of re-entry switches can be wired in parallel so that, for example, the system can be temporarily disabled from either the front door or the main bedroom.

The alarm system is very simple to use. The panic and fire alarm side of the circuit is permanently enabled and can be operated at any time. The anti-burglar section is enabled only when the main key switch is set to the on position. If LED2 lights at the moment of turn-on it means that part of the burglary sensor system is either open or closed when it should not be, possibly due to an open door or a chair resting on a pressure mat, for example. The fault must be rectified before the system is put to full use.

If you leave the house or pass through a protected area after turning the system on, remember to use the re-entry facility before returning to the unit, or you'll sound the alarm and annoy the neighbours.

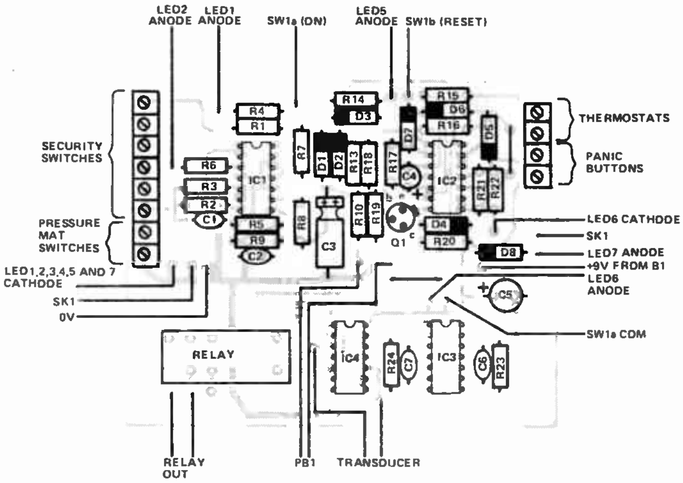
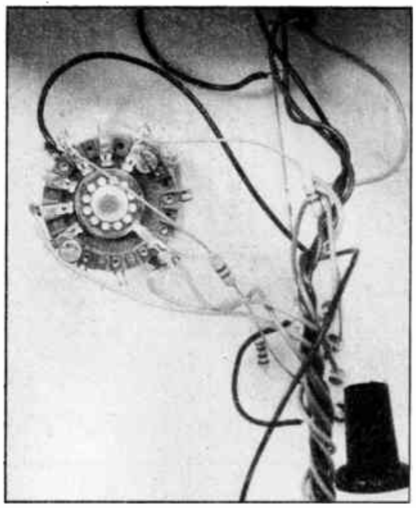


Fig.3 Overlay for the main board. Note that R11,12 and 25 are mounted off-board.



Details of the keyswitch wiring. The off-board resistors can also be seen.

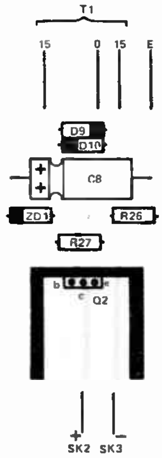


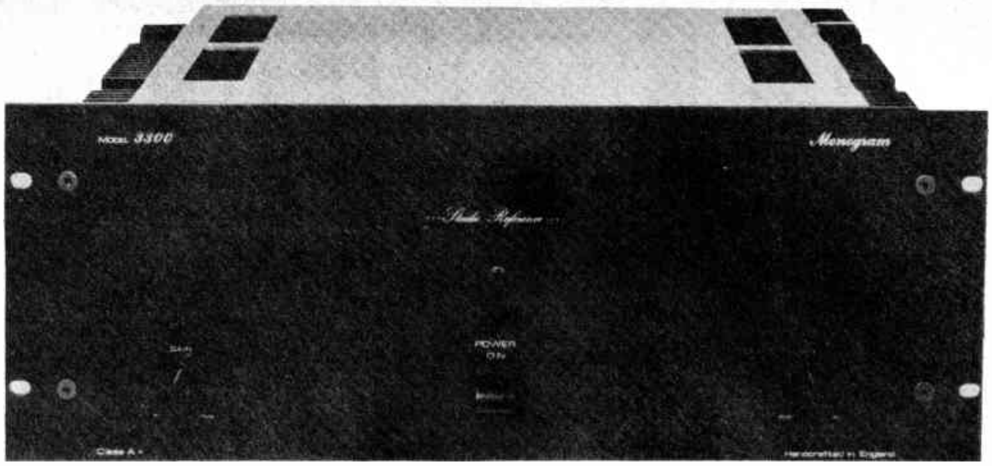
Fig.4 The charger overlay.

ETI

PARTS LIST

Resistors (all ¼W, 5%)	
R1,13,18,19	10k
R2,23	1M0
R3	56k
R4,6,11,12,14	820R
R5	100k
R7	470k
R8,9	4k7
R10	47R
R15	4M7
R16,24	22k
R17,22,25	1k0
R20	18R
R21	12k
R26	2k2
R27	22R
Capacitors	
C1,2	100n ceramic
C3	220u 16 V axial electrolytic
C4	100u 10 V tantalum
C5	100u 16 V electrolytic (PCB type)
C6	220n polycarbonate
C7	10n polycarbonate
C8	470 40 V axial electrolytic
Semiconductors	
IC1	4093B
IC2,3	4001B
IC4	4011B
Q1	BC109
Q2	TIP32A
D1,4,8,9,10	1N4001
D2,3,5,6,7	1N4148
ZD1	BZY88 2V7
LED1,4,7	0.125" green LED
LED2,3,5,6	0.125" red LED
Miscellaneous	
T1	9-0-9 @ 75 mA
SW1	two-pole six-way wafer key switch
SK1	DC socket and plug
SK2,3	4 mm sockets (and plugs)
TX1	piezo-electric transducer
RLA	6 V DPCO, PCB-mounting

PCB-mounting terminal blocks; Verocase (order code 202-21031G); case for charger unit (order code Samos 002).



Although not strictly part of the review intended, I could not resist the prospect of a chance at the 3300 power amp. Rated at slightly less than twice the power of the 109, it promised to be an interesting beast under test.

As you can see from the test results it did not disappoint. The PSU contained herein is rated in excess of 1 kW in order that constraints upon this part of the design never become a stricture on the amplifier as a whole.

The sound quality produced by the 3300 is little different to that of the 109, as might be expected. If anything I'd give the 109 the slight edge under dynamic conditions, using a domestic system. Maybe the separate supplies, although individually lower rated impart to it a better coherence under hard drive. Otherwise all comments made herein on the 109 apply equally to the 3300.

The unit was primarily designed for studio usage, of course and so would be much more rugged — witness the massive metal work, ¼" jack connectors (or Cannons), fan mounting holes etc. etc.

The normal recommended retail of the beast is around £650, but interested parties should contact Monogram for the present price which is more £200 less than this, since the model is being phased out to allow the c..npany to concentrate on the 106/109 range. At under £400 the 3300 is excellent value indeed for those needing a lot of power into any loading conceivable.

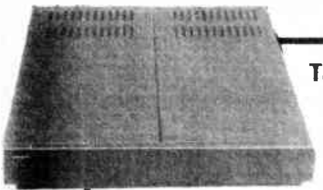


TABLE 2

Table 2. Test results: Monogram 109 and 3300 power amplifiers

	109	3300
Power output: (both driven per channel)	120 W (8R) 274 W (4R) 430 W (2R)*	215 W (8R) 347 W (4R)*
Transient delivery:	>300 W (4R)*	>400 W (4R)*
Half-power bandwidth:	10 Hz-70 kHz	10 Hz-50 kHz
THD:	<0.05% (20 Hz-20 kHz at 120 W)	<0.05% (20 Hz-20 kHz at 200 W)
Damping factor:	>150 (20 Hz-20 kHz) >400 (<1 kHz)	>100 (20 Hz-20 kHz) >400 (<1 kHz)
Hum and noise:	−100 dB (ref 100 W)	−120 dB (ref 200 W)
Input impedance:	10k	15k-22k (gain setting)
Input sensitivity:	0 dB (775 mV)	0 dB (775 mV)
Price:	£340 (including PSU)	£POA (see above).

*Burst power and sustained power into 2R is given in this form because both these amps exceeded my test rig capabilitilies. From current measurements it would appear that the 109 delivers in excess of 450 W into 2R and the 3300 around 560 W. Both figures are the highest I have measured from a domestic amplifier and illustrate an unrivalled ability to provide undistorted and unclipped power into any load.

As the output impedance is less than 600R, long leads to power-amps are no problem, as the load will not affect frequency response.

Overall the standard of construction is very high indeed and a clever PCB layout minimises both interwiring and noise/hum paths within the box. A toroidal transformer is fitted, to aid the hum figures still further.

As you can see from the spec the standard is a high one — and the 106 exceeded that spec on every parameter I measured. In some cases it bettered the limits of my test gear, thus leaving me simply to agree that the figures are 'reasonable'!

Powerful Amps

The 109 power amps are separately cased, with the PSUs also residing in their own matching case. The two amp cases share a common front panel and are linked together by the casing system. Sensible power connectors are employed, and good large screw terminals are provided for speaker connections. Little points maybe, but correct connectors indicate that thought has been expended on all aspects of the design.

Input is via phono plugs — and all preamp outputs will be of this variety also. Being a confirmed hater of all things DIN, I find this most encouraging!

The PSU for each channel — they are separate — is rated at more than that required for 100 W output (we will return to this later). Toroidal transformers are again present and the constructional standard is impeccable. It is nice to be able to praise a British company for finish and construction for a change — too often is this the sole preserve of Oriental offerings.

Circuitry is of a mode entitled 'enriched bias' which means that for 90% of the available output, the amplifier runs in pure class A and will only switch to AB at powers in excess of that 90%. In this way class A sound can be obtained without the otherwise necessary hardware.

It is worth noting that Monogram marketed a design using this configuration many years before the Japanese production

Multiple triggering is rare, even at high noise levels, due to a hysteresis level detector (4093) and the use of CMOS circuitry throughout means low current consumption (less than 50 mA, inclusive of the light source current) and therefore portability. A stabilised voltage supply (78L05) for certain parts of the circuitry ensures a stable operation of the preamp and reliable frequency reading for a battery voltage as low as 7 V.

Construction

The construction of this project should present no problems if the overlay and photographs are followed — the only precautions are to avoid touching the IC pins in case of damage by static, and to keep the PCB clean in order to minimise leakages around IC2. The sensor assembly is fairly easy to make, using a small piece of scrap aluminium and a Velcro band. The leads to the sensor should be shielded — see the photographs.

To calibrate the unit a reference frequency has to be fed to the input — the simplest method is to place an LED in front of the phototransistor. The reference frequency required is quite low and can be obtained either from a low frequency generator or by dividing down from a higher frequency (or the 50 Hz mains). With the reference at 0.66 Hz, adjust PR2 to give a zero reading on the scale — this corresponds to the minimum reading of 40 beats per minute. Now alter the reference to a suitable upper limit (eg 2 Hz gives an FSD of 120 beats per minute), and adjust PR1 to give FSD on the meter.

Many interesting experiments can be set up with this piece of equipment, although it must be pointed out that non-approved instruments cannot be used for medical purposes. Female readers wishing to participate in experiments on the heartbeat rate of staff members should apply to the editorial department at the usual address.

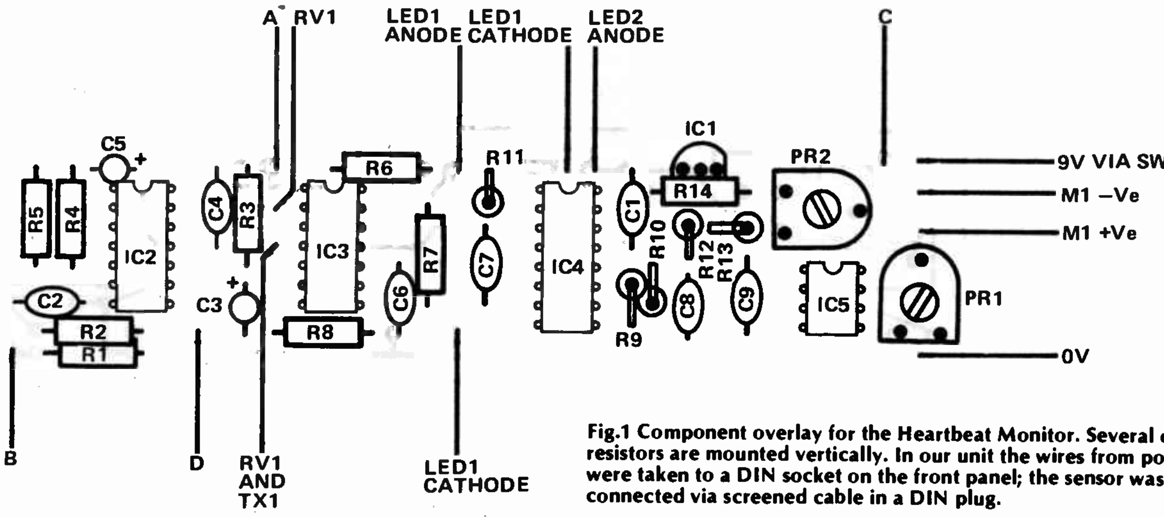


Fig.1 Component overlay for the Heartbeat Monitor. Several of the resistors are mounted vertically. In our unit the wires from points A-D were taken to a DIN socket on the front panel; the sensor was then connected via screened cable in a DIN plug.

HOW IT WORKS

The circuit consists of a signal extractor and conditioner, followed by a very low frequency meter.

Infra-red light is emitted from the LED in OCS1 and a small fraction is reflected back to the phototransistor from the bloodstream. The photocurrent from the sensor is sunk by IC2a, an enhancement mode MOS transistor which acts as an adjustable current source with a gate voltage of about 3 V. The R2/C2 network fixes the rate at which current sinking can alter: any variations with a higher frequency are passed on to the next stage via C3.

Transistors IC2b,c form an inverting pair polarised to half supply voltage by R3 — the gain of this stage is fixed by the ratio of C3 to C4. C5 transmits the signal to the next stage formed by inverting pair IC2d,e, polarised by R4 and offset by R5 so as to switch over only on the positive peaks of the signal. This is a high gain stage as the signal is fed directly to the inverter input.

All the previous stages are working at very high impedances as the photocurrent is of the order of nanoamperes. All the MOS transistors are working linearly in this circuit.

Any noise in the signal is removed by IC3a, a Schmitt NAND gate, which provides a clean digital impulse for the frequency meter. The output of IC3a also drives LED1, giving a visual indication of the beat rate, and gates on audio oscillator IC3b. Gates IC3c,d effectively double the driving voltage to the audio transducer.

The frequency measurement is made by locking IC4, a 4046B phase-locked-loop, onto the heartbeat frequency and displaying the control voltage of the PLL VCO on an analogue meter. This is just about possible if C7 is a good quality capacitor and with high resistances at R9 and R10. The linearity is very good, and the design of the low-pass network means that the instantaneous frequency of each beat can be displayed. A smoothed voltage from C9 is buffered by IC5 in a voltage follower configuration and both, the maximum and minimum frequencies can be calibrated using PR1 and PR2 respectively.

BUYLINES

The only unusual component used in this project is OCS1, a TIL139 optically-coupled switch used as the sensor. This device is available from Marshall's and Watford Electronics. The PB-2720 is available from Ambit International.

You should be able to get Velcro from the haberdashery department of any large department store.

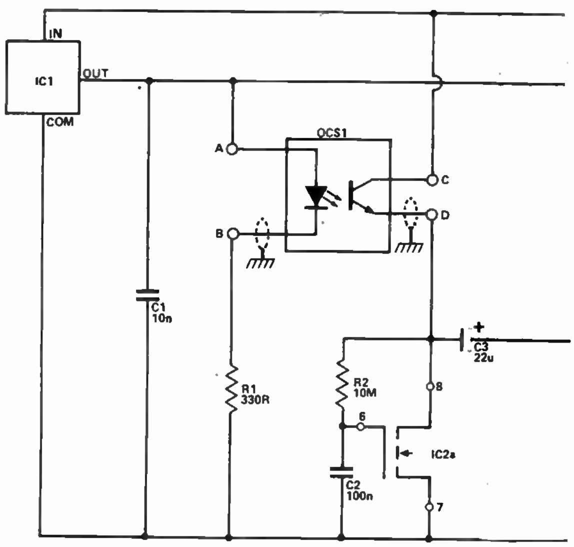
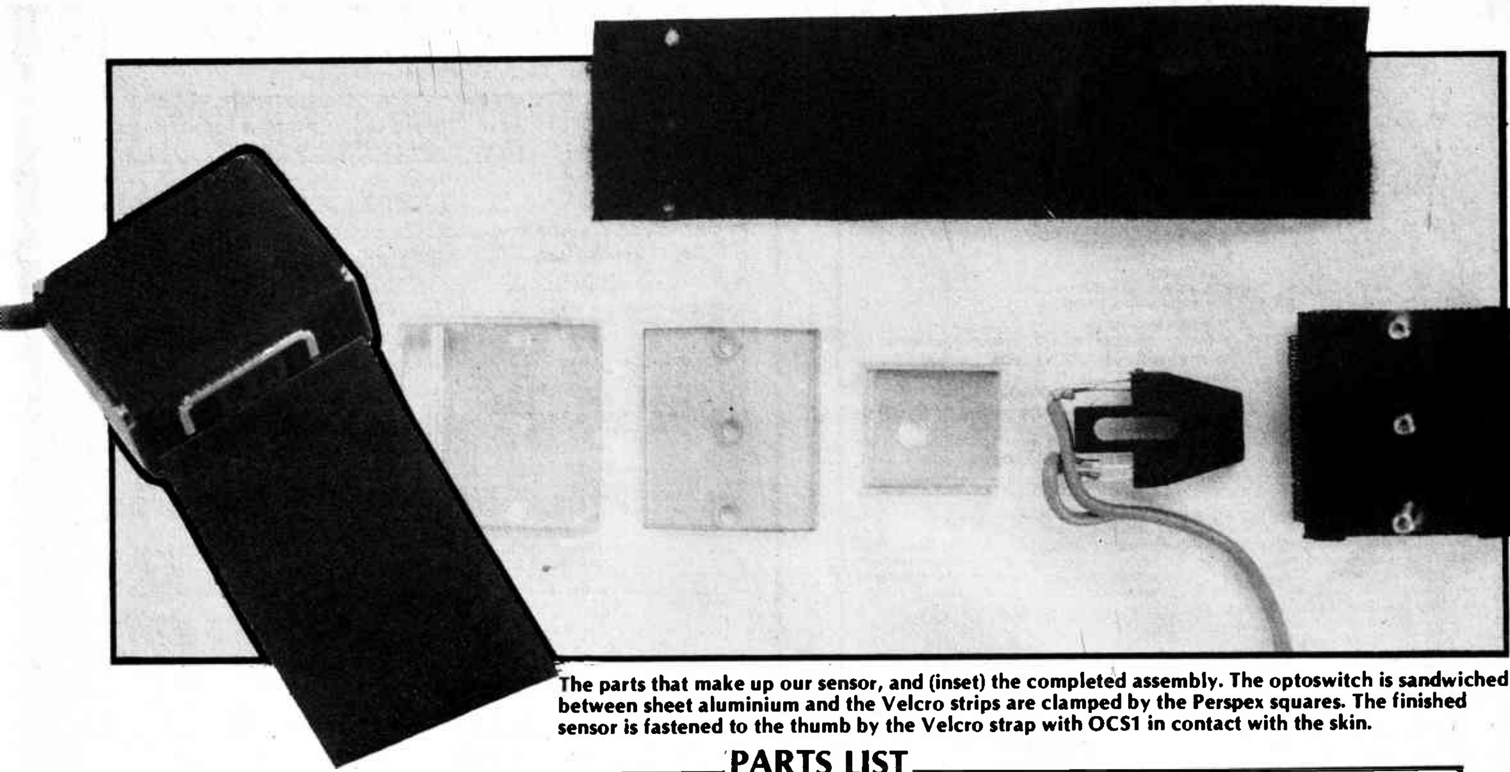


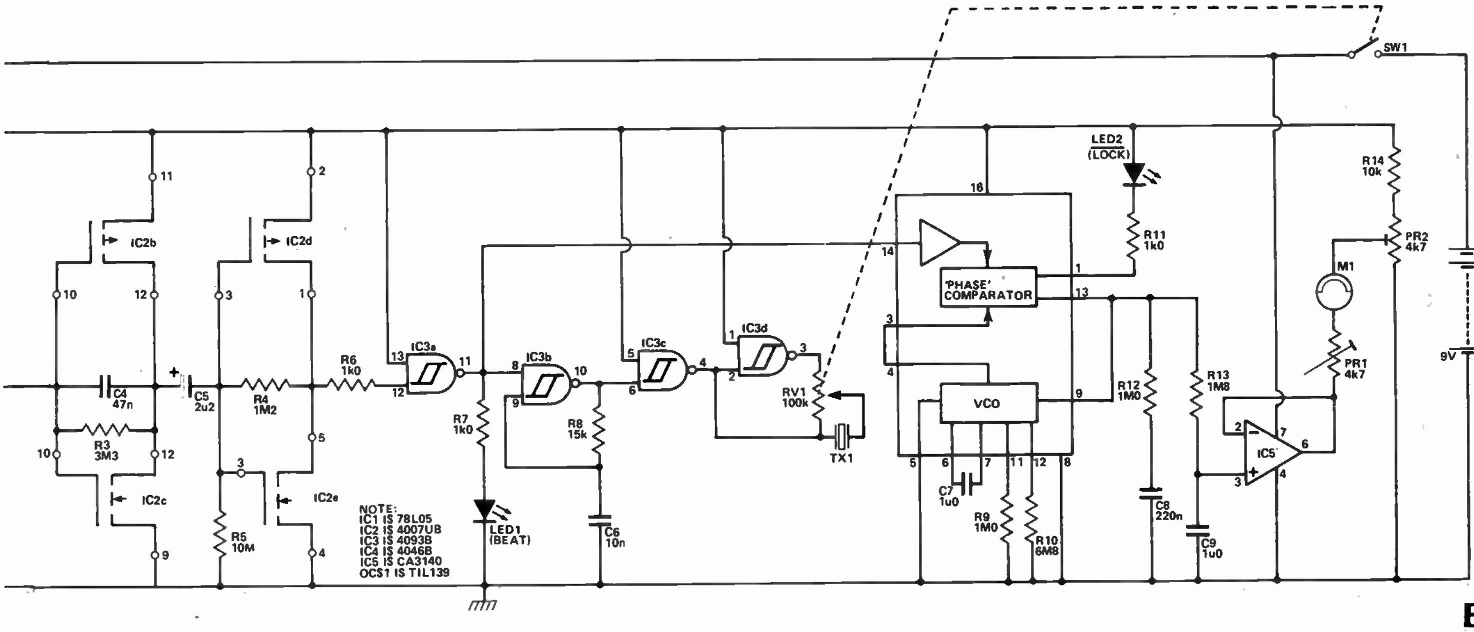
Fig.2 Circuit diagram of the complete unit.



The parts that make up our sensor, and (inset) the completed assembly. The optoswitch is sandwiched between sheet aluminium and the Velcro strips are clamped by the Perspex squares. The finished sensor is fastened to the thumb by the Velcro strap with OCS1 in contact with the skin.

PARTS LIST

Resistors (all ¼ W, 5%)	
R1	330R
R2, 5	10M
R3	3M3
R4	1M2
R6,7,11	1k0
R8	15k
R9,12	1M0
R10	6M8
R13	1M8
R14	10k
Potentiometers	
RV1	100k linear with integral switch
PR1,2	4k7 miniature horizontal preset
Capacitors	
C1,6	10n polyester
C2	100n polyester
C3	22u 16 V tantalum
C4	47n polyester
C5	2u2 35 V tantalum
C7,9	1u0 polycarbonate
C8	220n polycarbonate
Semiconductors	
IC1	78L05
IC2	4007UB
IC3	4093B
IC4	4046B
IC5	CA3140
OCS1	TIL139
Miscellaneous	
TX1	PB2720
M1	1 mA FSD moving coil meter
Battery holder (six HP7)	



term current delivery and, equally important, current-sinking capability far in excess of any known Class AB power amplifier of similar rated output power.

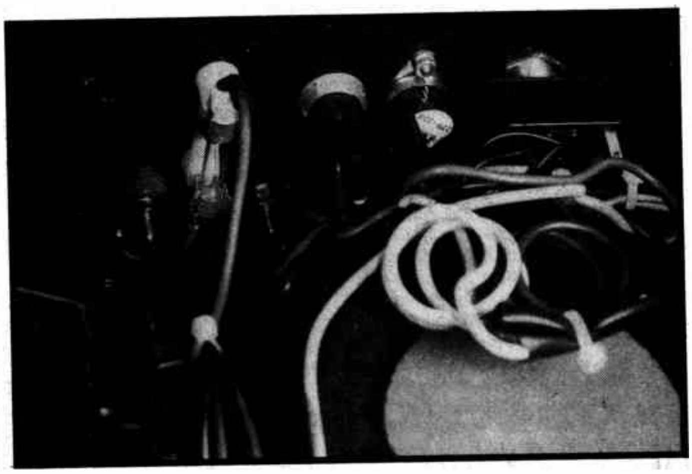
Amp Of Substance

The output stage is quite substantial, using a total of six 250 W power transistors. Fairly 'old-fashioned' power transistors have been used (the MJ4502/802 family) in preference to some of the higher performance devices now available. They have been chosen because the die used to mount the semiconductor junction is of a large area; the device is quite rugged and can handle high currents. The short-term current capability of the output stage is, in fact, of the order of 90 A, somewhat in excess of the current capability of the wiring!

The power supply is equally substantial, using a 500 VA toroidal mains tranformer and two massive computer grade reservoir capacitors. These components are expensive but essential. The rest of the construction is equally massive with a steel chassis supporting six very large heatsinks. However, construction is straightforward provided that the builder has strong arm muscles, and circuit alignment simple — there are but two adjustments — quiescent current and DC offset voltage nulling.

Construction

The constructional layout shown in the drawings and photographs should be followed as closely as possible. (With such high currents flowing down the cable forms, problems can easily occur if too many changes are made.) The heatsinks and the power supply components are assembled onto the baseplate and wired up in accordance with the wiring diagram. The recommended wire types and gauges should be adhered to.



Close-up of fuse wiring on back panel.

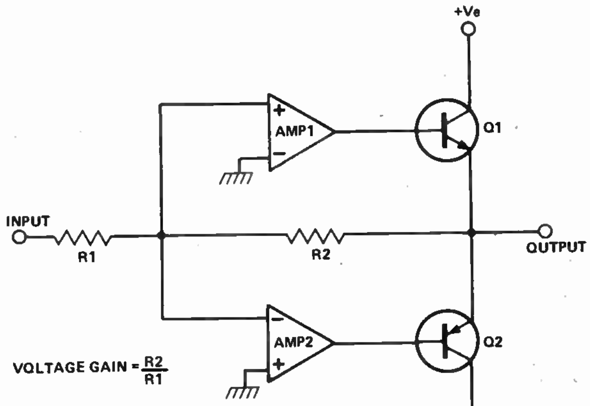


Fig.1 Simplified block diagram of the power amp.

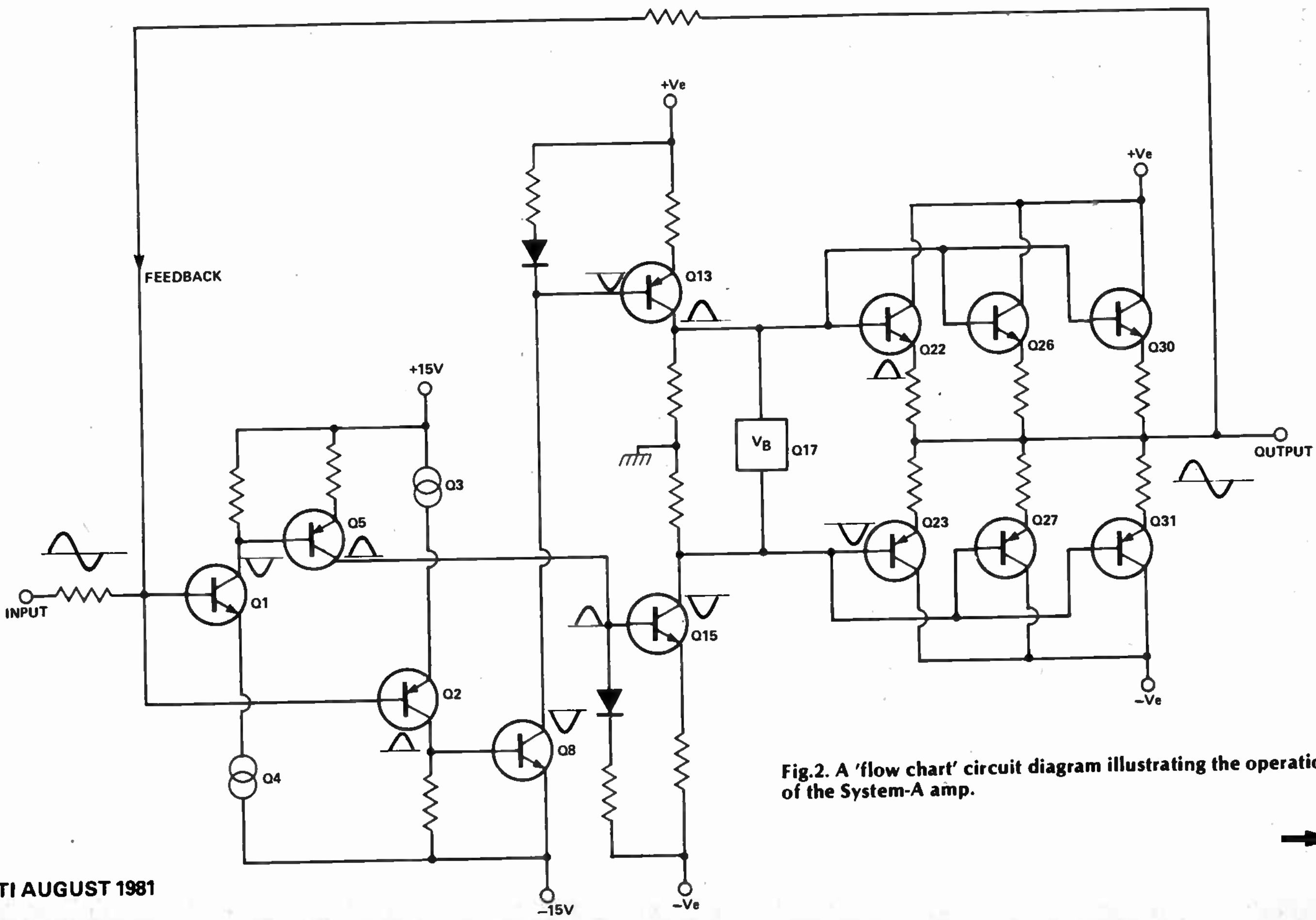
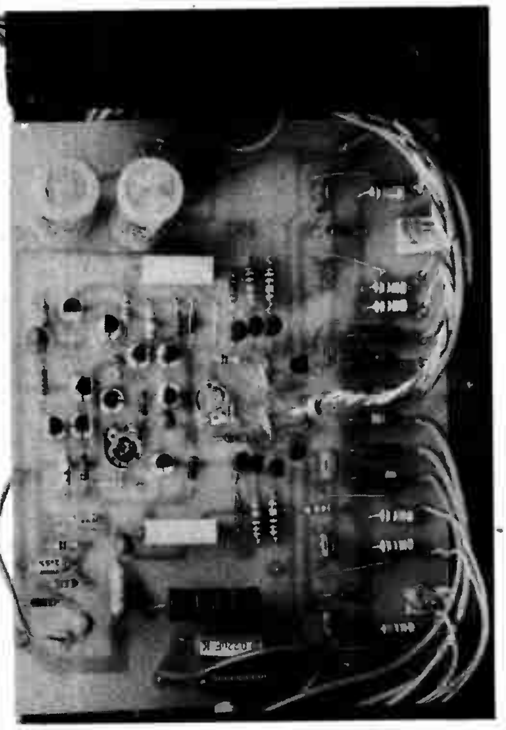


Fig.2. A 'flow chart' circuit diagram illustrating the operation of the System-A amp.



Left: a detail shot showing how the PCB is wired into the case.

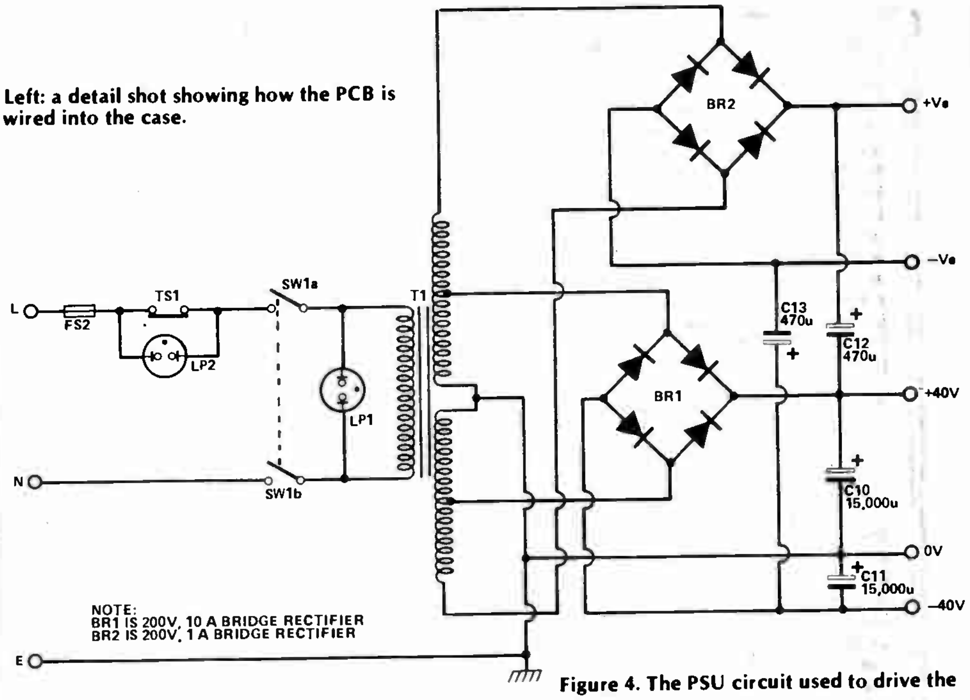


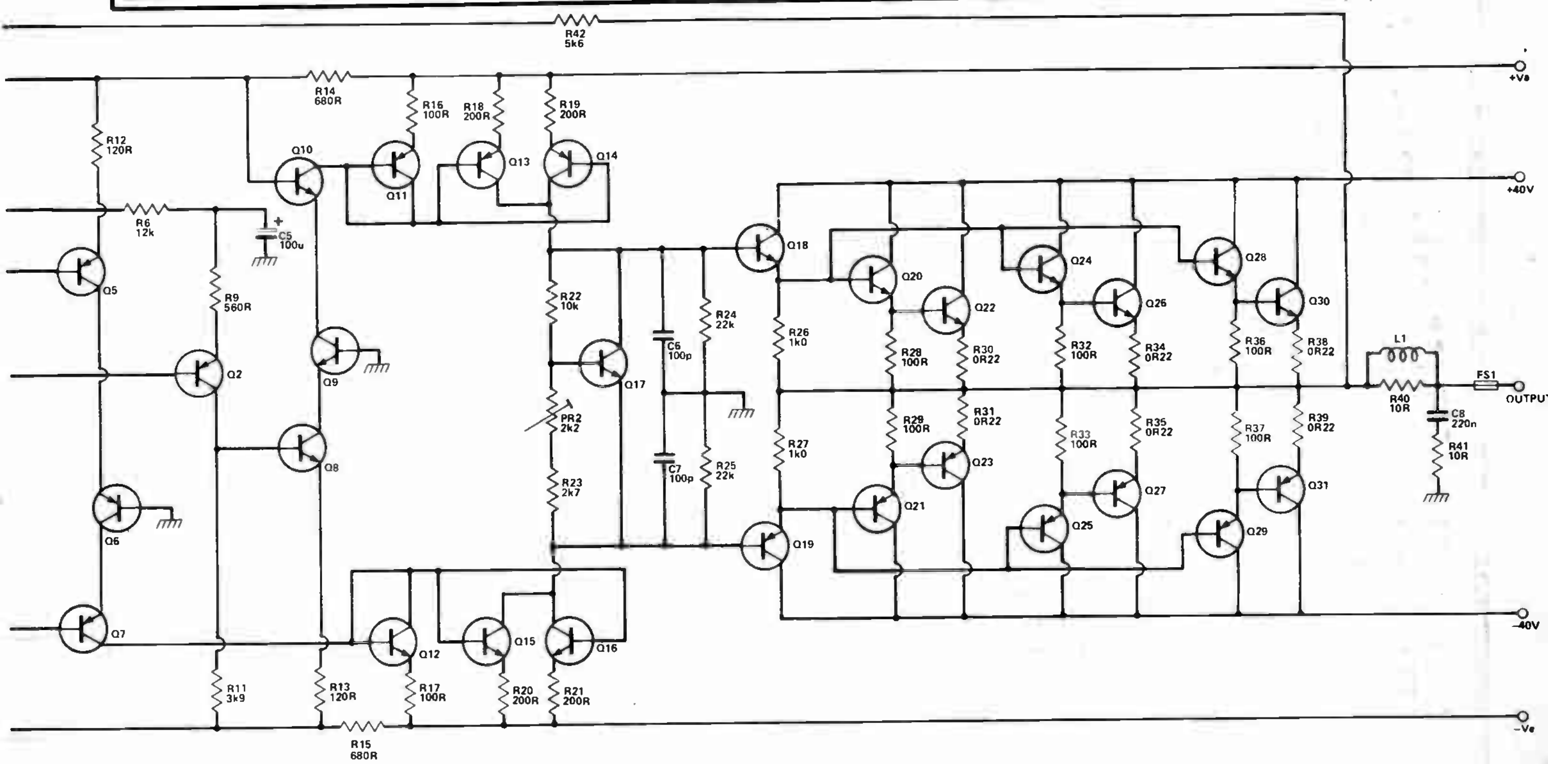
Figure 4. The PSU circuit used to drive the power amps.

BUYLINES

Most of the components specified are readily available from the usual suppliers except for the connectors and the low noise transistors. The board-to-board gold-plated connectors (horizontal, 45°) are type 434-172, and the vertical input-to-board connectors are type 434-188. These are available from RS Components Ltd, and can be ordered via a local stockist.

Kits of parts for the System A amplifier are available from Jelgate Ltd, 215 High Street, Offord Cluny, Cambs. Prices are as follows:
Preamp Kit 1 containing two chassis (preamp and PSU), toroidal transformer, and all the chassis-mounting components; £28.
Preamp Kit 2 containing the A-PR and A-PSU PCBs and all components; £26.
Preamp Kit 3 containing A-MM/A-MC PCB and components; £12 for either version.
Set of four input transistors, selected for low noise; £2.
Power Amp Kit 1 containing all the metalwork, heatsinks and chassis-mounting components; £105.
Power Amp Kit 2 containing transformer, capacitors, power supply components and power transistors; £65.
Power Amp Kit 3 containing A-PA PCB and components; £23.

All these prices are exclusive of VAT and carriage. The cases are all ready-painted and screen-printed. Items can be bought separately; a comprehensive price list can be obtained from Jelgate.



PARTS LIST

Resistors (all ¼ W, 5% except where stated)

R1	47k
R2,10,26,27	1k0
R3,22	10k
R4,9	560R
R5,11	3k9
R6	12k
R7,8,23	2k7
R12,13	120R
R14,15	680R 4 W
R16,17,28,29,32,33, 36,37	100R
R18,19,20,21	200R
R24,25	22k
R30,31,34,35,38,39	0R22 2W5
R40	10R 1 W
R41	10R 2 W (not wirewound)
R42	5k6
R43	18k
R44	300R

Potentiometers

PR1	20k miniature horizontal preset
PR2	2k2 miniature horizontal preset

Capacitors

C1	10u 35 V tantalum
C2	1n0 polystyrene
C3	100p polystyrene
C4,5,9	100u 6V3 tantalum
C6,7	100p miniature ceramic
C8	220n polycarbonate
C10,11	15,000u 50 V electrolytic (Sprague type 36D)
C12,13	470u 63 V electrolytic (PCB type)

Semiconductors

Q1,4,8,9,10,17,18	MPSA06
Q2,3,5,6,7,19	MPSA56
Q11,13,14	MPSA93
Q12,15,16	2N6515
Q20,24,28	BD379
Q21,25,29	BD380
Q22,26,30	MJ802
Q23,27,31	MJ4502
ZD1,2	15 V, 1W3

Miscellaneous

SW1	DPST mains switch
TS1	Thermal cut-out switch
LP1	Red neon
LP2	Orange neon
FS1	1¼" 5 A—10 A (to suit loudspeaker)
FS2	20 mm 3.15 A

Toroidal transformer, 1¼" chassis-mounting holder, 20 mm panel-mounting holder, phono input socket, loudspeaker screw-terminals, chassis and heatsinks, mounting hardware.

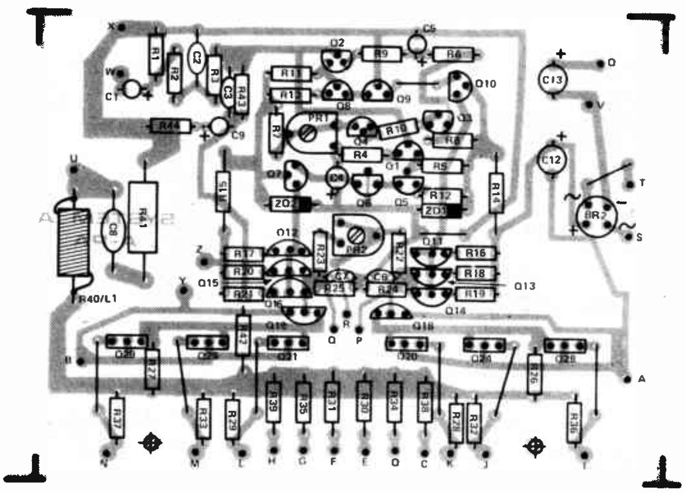
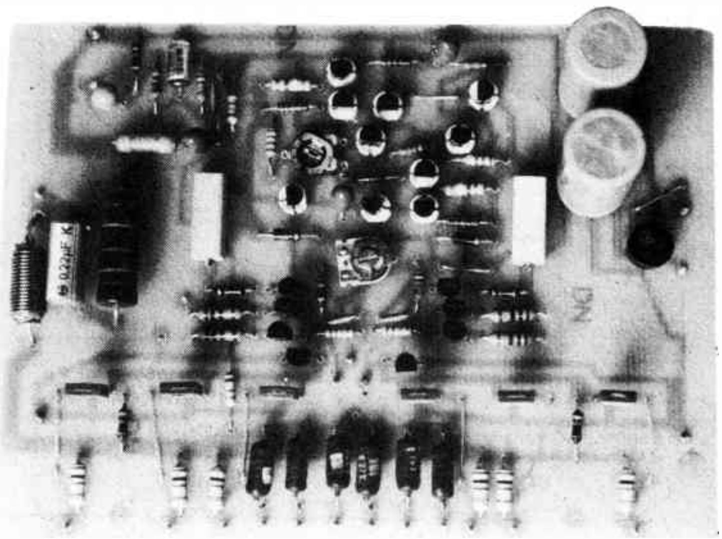


Figure 5. Component overlay for the power-amp PCB.



Next month: we conclude the amplifier project with the PSU and interwiring details.

PIN CONNECTIONS

A	+40 V	N	Q31 base
B	−40 V	O	Wire link to pin Y (underside of PCB)
C	Q30 emitter	P	Q17 collector
D	Q26 emitter	Q	Q17 emitter
E	Q22 emitter	R	Q17 base
F	Q23 emitter	S	Transformer
G	Q27 emitter	T	Transformer
H	Q31 emitter	U	Output
I	Q30 base	V	Wire link to pin Z (underside of PCB)
J	Q26 base	W	Input
K	Q22 base	X	Ground
L	Q23 base		
M	Q27 base		

amplify the pipe tones, but violins and brass also need 'space' to develop proper tonality, and even amplified guitar will sound thicker and richer in an acoustically 'live' environment.

Second, a musician needs to hear both his own instrument and those of the others in the group; this is not always easy in studios where the total sound pressure level attenuation over 10 feet can be as much as 56 dB! For the recording engineer, however, this very heavy damping is necessary — some would say essential — if he is to make clean recordings. Too much acoustic reverberation produces a muddy, bass-heavy sound from individual instruments and will cause 'spill' (acoustic crosstalk between a sound source and adjacent microphones), reducing the separation between tracks of the recording and probably resulting in a blurred stereo perspective and/or further loss of clarity.

Critically damped acoustics allow the engineer maximum creative freedom and control. Reverberation and tonality can be easily adjusted using the sophisticated electronics of the mixing console and 'outboard' signal processers, whereas he has very limited influence over the acoustic characteristics of the studio itself. In fact there is nothing 'magic' about acoustically 'dead' rooms; many producers and musicians will avoid them at any cost. The ultimate criteria is 'the sound', so that one studio will develop a reputation as a good rock'n'roll studio while another will be popular for disco or advertising jingles.

In recent years, the design and construction of recording studios has itself become an industry, geared to producing the 'perfect' recording environment. Inevitably this involves a compromise between the conflicting requirements of engineers and musicians. A practical solution is to provide more easily

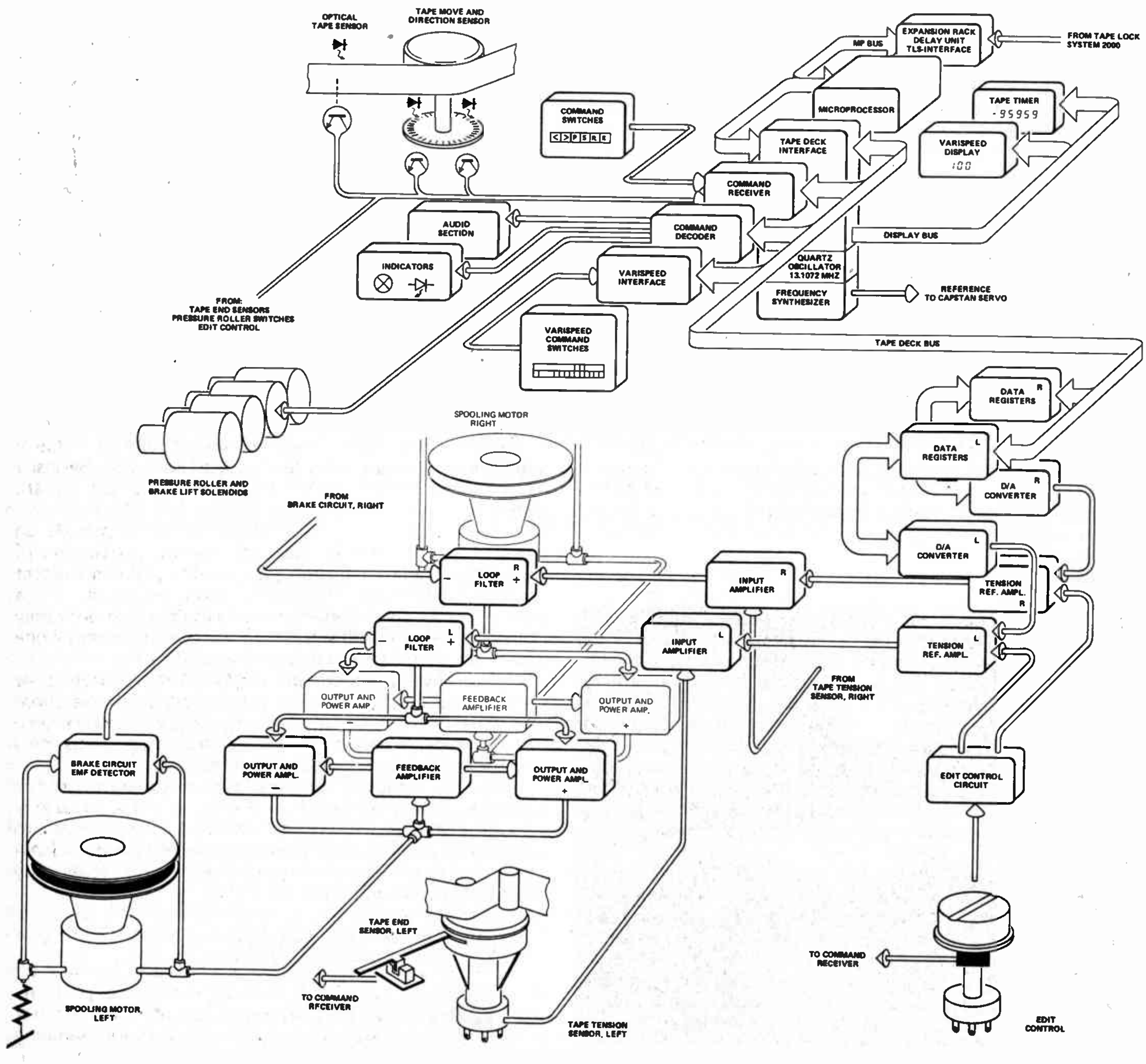


Fig.1 Block diagram showing the spooling motor controls and sensors of a multitrack recorder/reporter (Studer A800).

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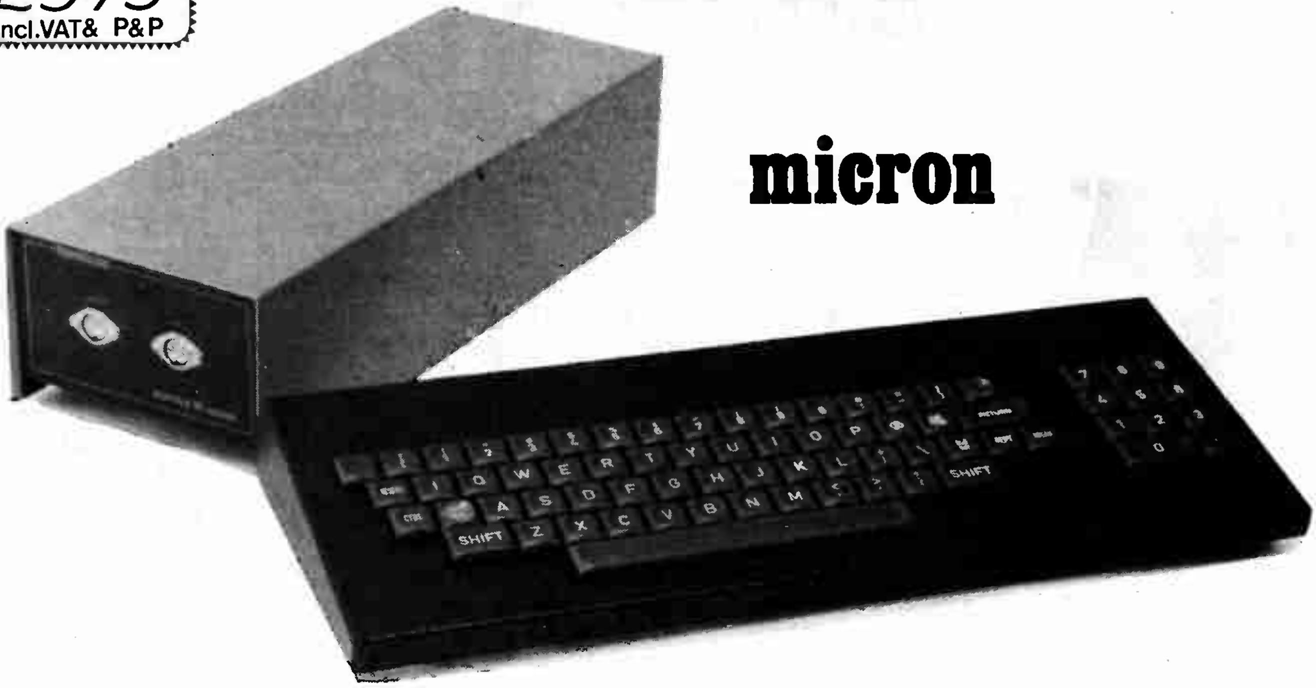

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SPOT DESIGNS

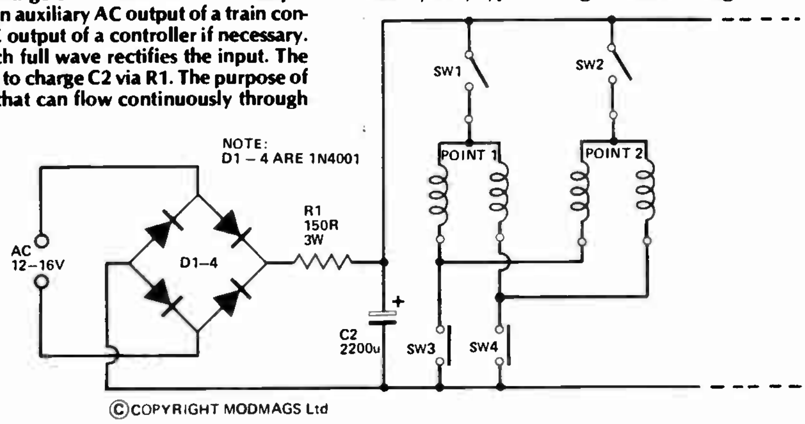
Points Controller

The electric points used in model railways are operated by a simple mechanism which utilises two solenoids, providing movement in opposite directions. Thus, briefly connecting power to one solenoid changes the state of the point and a short burst of power to the other solenoid changes it back to its original state. It is essential that the power is only applied in short bursts, since the current consumption of each solenoid is typically in the region of 1-2 A, and continuous power would almost certainly cause the solenoid to burn out.

It is possible to eliminate any chance of accidentally destroying a solenoid by using a capacitor discharge controller such as this simple design. This takes its power from an auxiliary AC output of a train controller. It will also work from a DC output of a controller if necessary. D1-4 form a bridge rectifier, which full wave rectifies the input. The resultant pulsing DC signal is used to charge C2 via R1. The purpose of R1 is merely to limit the current that can flow continuously through the points solenoids to a safe level (about 100 mA or so).

The high current required to activate the point is available from C2, but this can only provide short bursts of current as it quickly discharges through the low impedance provided by the solenoids. The value of C2 is chosen to give pulses of power that are sufficiently long to give reliable operation of the point, but offer no possibility of burning out the solenoids. SW1 or SW2 is closed to select the appropriate point and then either SW3 or SW4 is operated to switch the point over.

Although only two points are shown in the circuit diagram, obviously any number of points can be connected to the unit, an additional switch being required for each one. SW3 and SW4 must be heavy duty types having a current rating of at least 2 A.



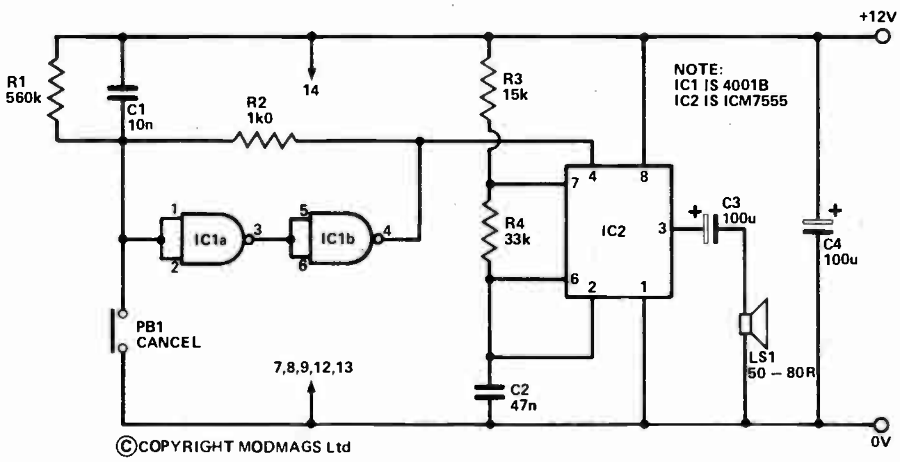
Seatbelt Reminder

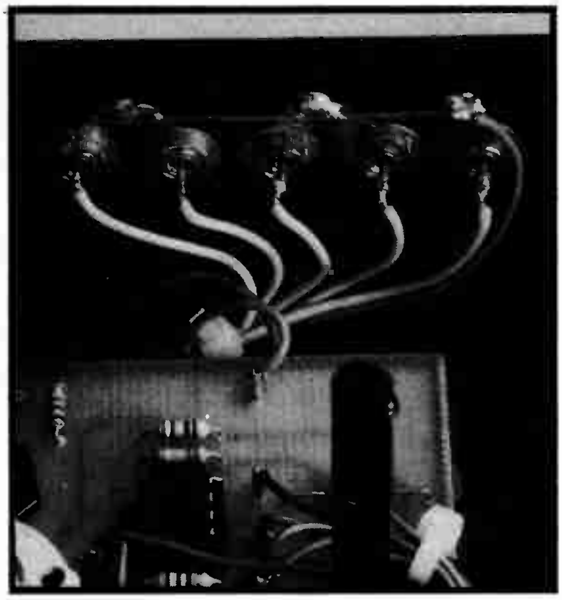
This simple seatbelt reminder circuit connects to the battery via the ignition switch, and sounds an audible reminder signal when the ignition switch is turned on. The audio signal is cancelled by operating a push button switch.

The audio signal is generated by IC2 which is an ICM7555 (the CMOS version of the standard 555) used in the astable mode. The CMOS version is preferable in this application since it has a higher maximum supply voltage rating and is less likely to be damaged by an excessive supply voltage. C3 couples the output of IC1 to a high impedance loudspeaker which should not have an impedance of less than 50R.

The oscillator is controlled by the voltage fed to pin 4 of IC2; with a voltage of less than about 0V5 the oscillator is disabled. IC1 is a CMOS quad two-input NOR gate, but only two of the gates are used, and these have their inputs wired in parallel so that they operate as simple inverters. They are connected in series and have DC positive feedback via R2 so that a simple latch circuit is produced. C1 provides a positive input pulse to the latch so that initially the input (and therefore the output as well) assumes the high state. Thus the oscillator operates when power is first applied to the circuit, and the reminder signal is produced. Briefly operating PB1 takes the input (and output) to the low state, so that the unit functions properly when the ignition switch is operated again.

As the quiescent current consumption of the unit is less than 1 mA the unit does not have a detrimental effect on the car battery (which has a very high capacity), especially as the unit is only connected to the battery when the ignition switch is turned on.





Close-up of the flash output sockets. These are held in place on the front panel by the knurled nuts, which are rather hard to solder to; we drilled out solder tags to the right size to make the earth connections.

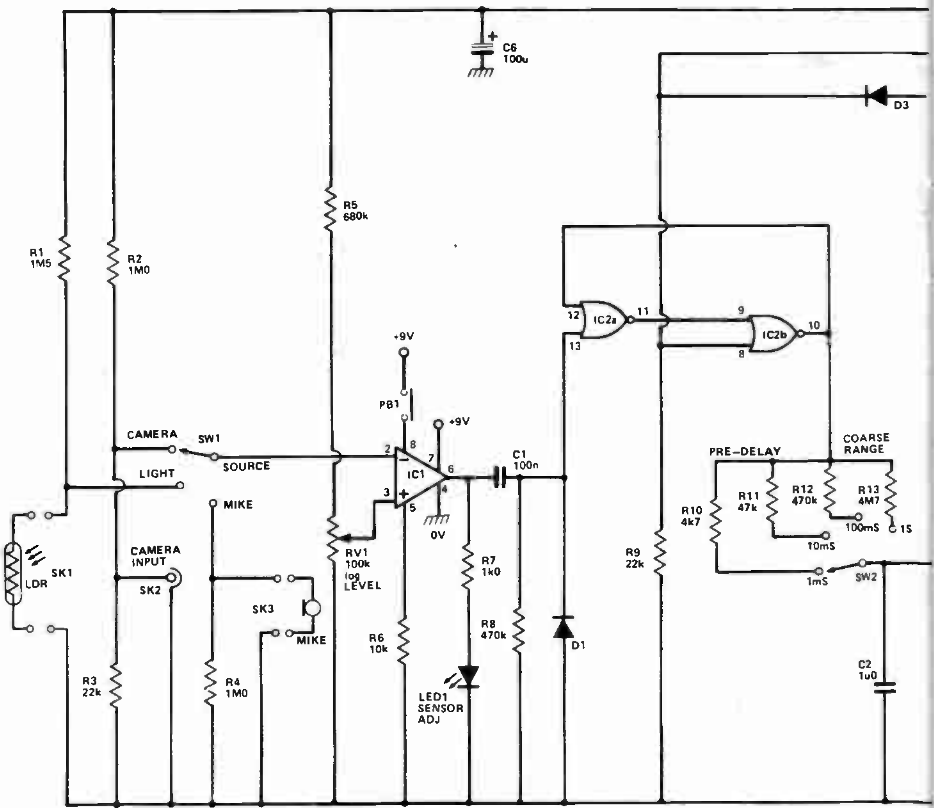


Fig.1 Circuit diagram of the Flash Sequencer.

HOW IT WORKS

The sensor is a simple level crossing comparator, the signal source being selected by SW1. Resistor R6 at the offset compensation input of IC1 provides an imbalance of the input differential stage, so that RV1 can set the threshold level both over and under 0 V. LED1 is an aid to adjustment and should be just flickering when RV1 is properly set.

A manual trigger is provided for test purposes. Irrespective of the input conditions of IC1, when PB1 is activated the strobe pin (pin 8) has direct control of the output. Thus pin 6 of IC1 is sent high and the flash sequence is triggered.

The next two stages are the pre- and sequence timers. They work in the same way, except for the enable conditions. The difficulty here is a reliable and repeatable delay. In all monostables, energy is charged and discharged between two levels. Our problem is that the stable level must be the same as the power off state; it must be reached in a much shorter time than the shortest delay (100 uS) without a negative supply to draw on; and the time control must be linear.

The stage works as follows: IC2a and IC2b lock to the charging position (low and high outputs respectively) as soon as an impulse is received through C1. C2 begins to charge through the range resistor. The output of IC3a is high, so IC4's inverting input is higher than its non-inverting input and its output is low. This output is fed back to IC3a's input so we have a steady state. As soon as the voltage on C2 reaches the limit set by RV2, IC4 switches high; IC3a switches low; the voltage at the inverting input of IC4 is zero, giving a Schmitt trigger action. A change of state can only occur now when C2 is discharged to 0 V (power off state). This is done by IC3b and C3, which was initially positively charged. As IC4 goes high, IC3b goes low. The voltage on the negative side of C3 is driven below zero potential. D4 is now forward biased and passes a current from C2 into C3. D3 and IC2b suppress the charging current. This continues until the voltage on C2 is just under 0 V, at which point IC4 switches over to its low position again.

The low to high transition of IC4 has been transmitted through IC2c and IC2d to the IC6 clock input. This results in the '0' output, which was at logic 1, going low, thus disabling the pre-delay stage and enabling the sequence timer through IC3c. At the same time output '1' goes high, triggering triac SCR1 and firing the first flash. The sequence timer (still enabled) operates in the same way as the previous stage, except that the charging current is continuously enabled and astable operation results. Each one of the impulses shifts the high output of IC6, successively triggering the following flashes until the '0' output is reached again. This disables the sequence timer and allows the pre-timer to receive a new impulse from the sensor, ready for a new cycle.

The output control elements are triacs, rather than SCRs, because not all electronic flashes conform to the 'positive centre/earth shield' standard connection.

PARTS LIST

Resistors (all ¼ W, 5%)

R1	1M5
R2,4,44	1M0
R3,9	22k
R5	680k
R6,16,17,18,19	10k
R7,26-34	1k0
R8,12,22	470k
R10,20	4k7
R11,21	47k
R13,23	4M7
R14,24	120k
R15,25	12k
R35-43	470R

Potentiometers

RV1	100k logarithmic
RV2,3	100k linear

Capacitors

C1	100n polycarbonate
C2,5	1u0 polycarbonate
C3,6	100u 10 V tantalum
C4	47u 16 V tantalum
C7	100n ceramic

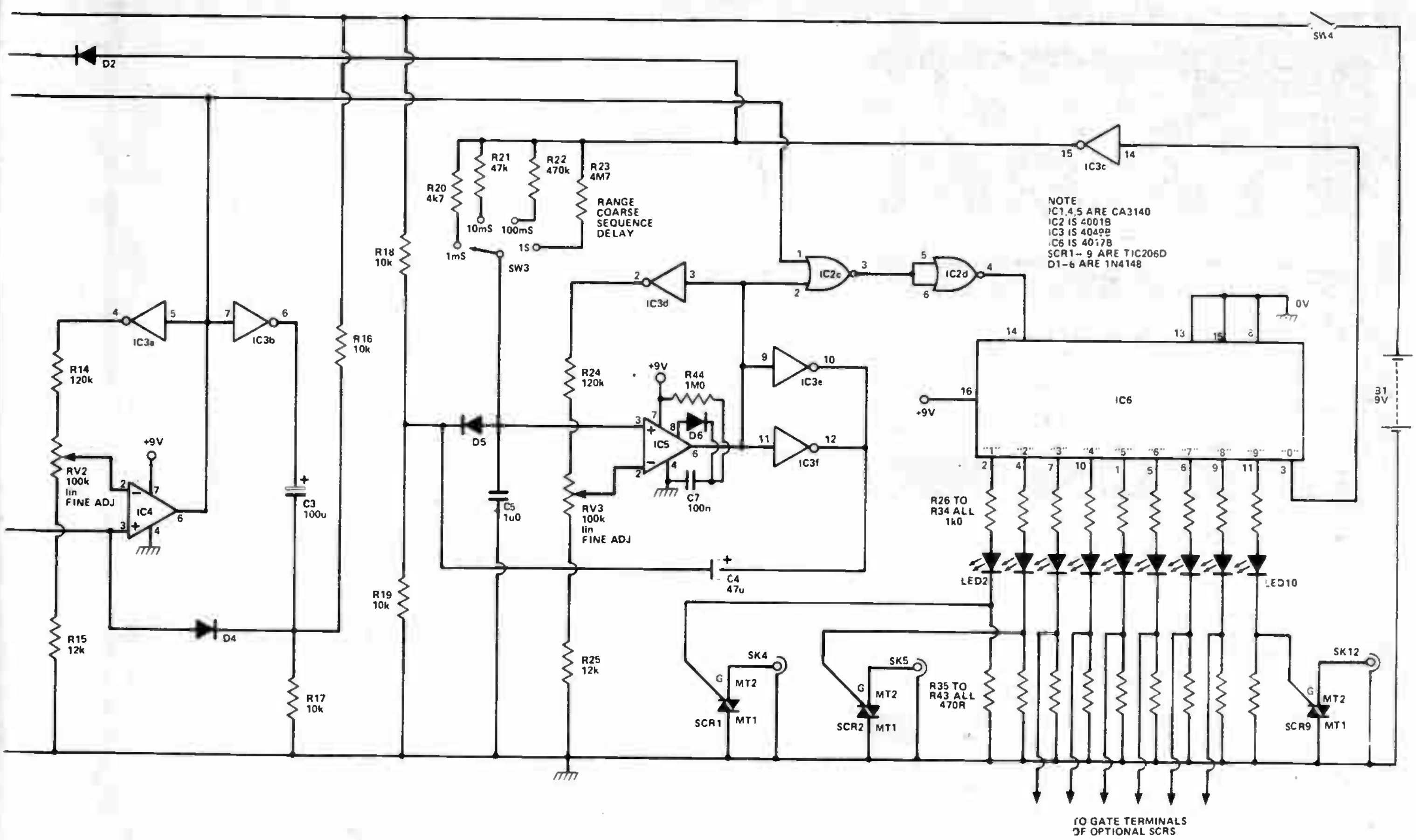
Semiconductors

IC1,4,5	CA3140
IC2	4001B
IC3	4049B
IC6	4017B
SCR1-9	TIC206D
D1-6	1N4148
LED1	0.125" yellow LED
LED2-10	0.125" red LED

Miscellaneous

PB1	push-button type SRM (see Buylines)
PB2	push-button type SRL (see Buylines)
SW1,2,3	one-pole rotary switch
SK1,3	phono socket
SK2,4-12	3 mm coaxial flashgun sockets (see Buylines)

Snap-in PP3 battery holder (Vero order code 202-21392J), case (see Buylines).



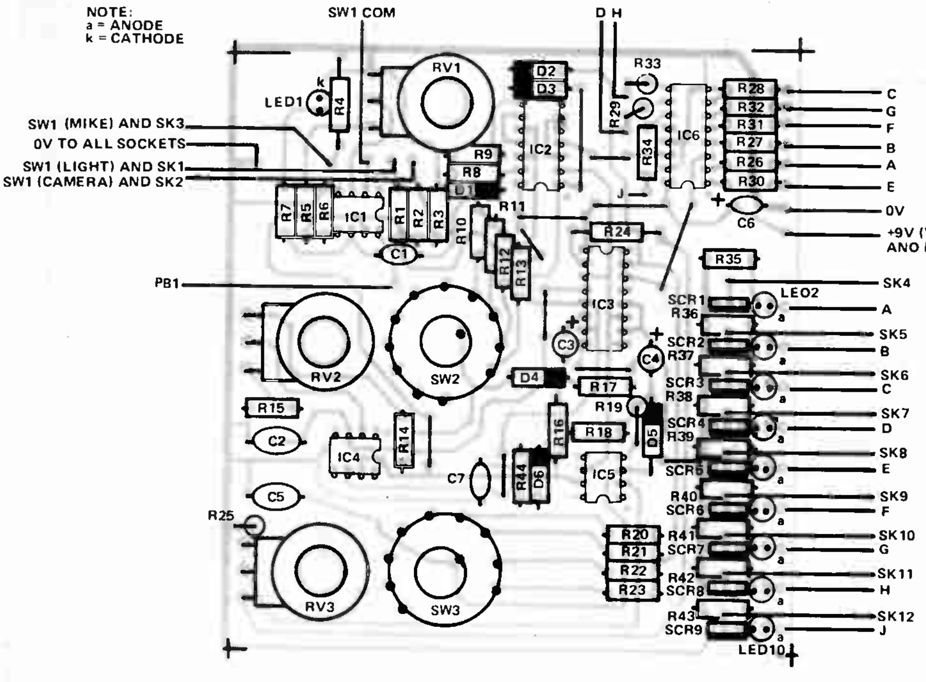
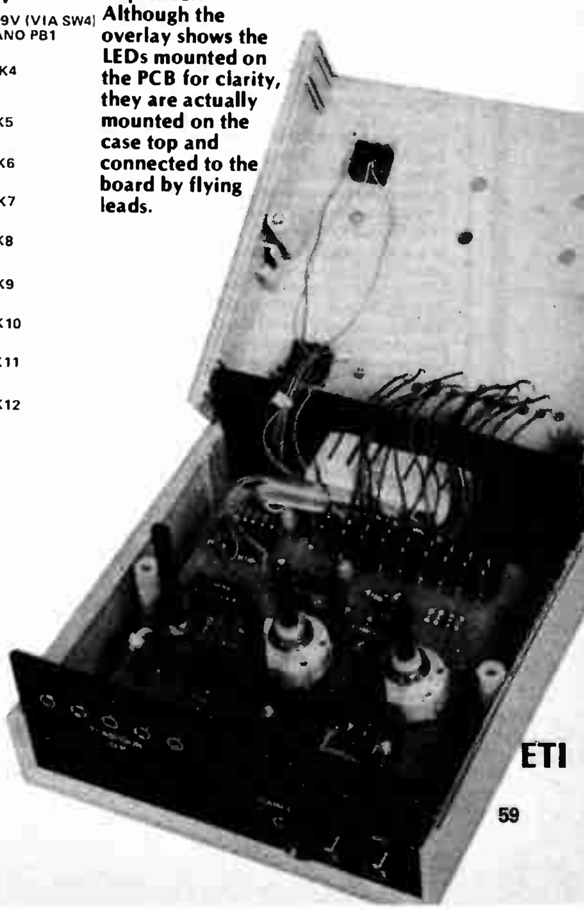


Fig.2 (left) Overlay for the sequencer. Some of the tags of SW2 and SW3 are cut off before mounting — the dots indicate which tags remain.



Below: inside the sequencer. Although the overlay shows the LEDs mounted on the PCB for clarity, they are actually mounted on the case top and connected to the board by flying leads.

BUYLINES

The 3 mm coaxial sockets (and a camera extension lead, if required), can be obtained from Vanguard Instruments, 233 High Street, Brentford, Middlesex. Telephone: 01-560 7667.

The case was chosen from the CM range offered by OK Machine and Tool Ltd, Dutton Lane, Eastleigh, SO5 4AA, telephone 0703 610944/5. The case order code is CM6-225.

PB1 and PB2 are available from Watford Electronics, and all the other components are common types and should cause no problems.

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DESIGNER'S NOTEBOOK

In this month's edition of Notebook, Ray Marston first looks at high impedance 'bootstrapping' techniques, and concludes by showing some unusual 4001B/4011B CMOS monostable and bistable circuits.

Bootstrapping is an in-phase (positive) feedback technique that can be used to greatly increase the apparent (AC) value of a resistor or reduce the apparent value of a capacitor. The technique is of particular value in the design of ultra-high input impedance AC amplifiers. We'll take a brief look at some practical examples of the technique in the first part of this edition of Notebook.

The easiest way to understand why the bootstrapping technique is needed is to look at the simple AC emitter follower circuit of Fig. 1. A major attraction of the emitter follower circuit is that it is capable of presenting a high input impedance to external signals, the actual impedance (looking into the base of the transistor) being equal to the product of the transistor h_{fe} (current gain) and the emitter load impedance (R_e): thus, the base impedance of the Fig. 1 circuit is equal to 220k. In practice, however, the emitter follower circuit cannot work unless it is DC-biased in some way, and in Fig. 1 potential divider R1-R2 is used as the biasing network. Unfortunately, this network is effectively in parallel with the input (base) of Q1 and thus reduces the true input impedance of the circuit to a mere 10k or so. Not very good.

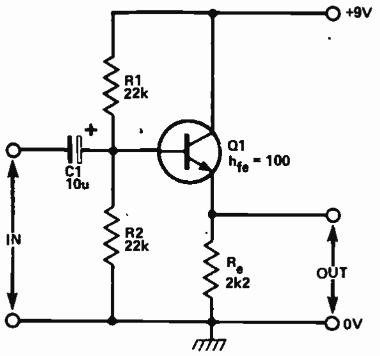


Fig.1 This simple AC emitter follower circuit has a true input impedance of only 10k or so.

Now look at Fig. 2, which shows how the so-called 'bootstrapping' technique can be used to raise the true AC input impedance of the circuit to nearly its theoretically-attainable maximum. Here, 22k resistor R3 is wired between the R1-R2 junction and the base of Q1, so the transistor is still correctly biased, and the AC input signal is fed directly to the base of Q1. The important point to note, however, is that the output of the emitter follower is AC-coupled back to the R1-R2 side of R3, so that in-phase AC signals appear on both sides of R3. What's the effect of this action?

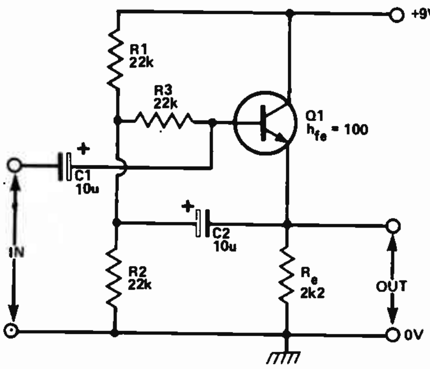


Fig.2 This 'bootstrapped' version of the AC emitter follower has a true input impedance of about 180k.

Suppose that our Fig. 2 emitter follower has an AC voltage gain of 0.98 (a reasonable figure). In this case, when an input signal is applied, all (100%) of the input signal appears on the 'base' side of R3, and an isolated but in-phase copy of this signal, with 98% magnitude, appears on the R1-R2 side. Consequently, the signal current flowing in R3 equals only 2% of that which would be expected from the original input signal alone. In other words, the AC input signal sees R3 as having a value of 100/2 x 22k, or 1M1: this impedance is in parallel with the base impedance of Q1, so the final input impedance of this bootstrapped emitter follower circuit works out at about 180k. Pretty good.

You can see, then, that the bootstrapping principle is very simple. By feeding an input signal to one side of passive component and a less-than-unity in-phase copy of the signal to the other side, the apparent impedance of the component can be increased. If 50% feedback is used, the impedance is doubled (100/50), if 90% feedback is used, the impedance increases by a decade (100/10). 99% feedback raises the impedance by a factor of one hundred (100/1), 100% feedback raises the impedance to infinity. If bootstrapping is applied to a resistor, the apparent resistance is increased: if the technique is applied to a capacitor, the apparent capacitance value is reduced. Clever stuff.

Bootstrapped Op-Amps

The basic bootstrapping technique can easily be applied to op-amp circuits, to produce non-inverting AC amplifiers with ultra-high input impedances, as shown by the examples of Figs. 3 to 7. In our first example (Fig. 3), the op-amp is biased by R1-R2 so that it can operate from a single-ended supply, and the input

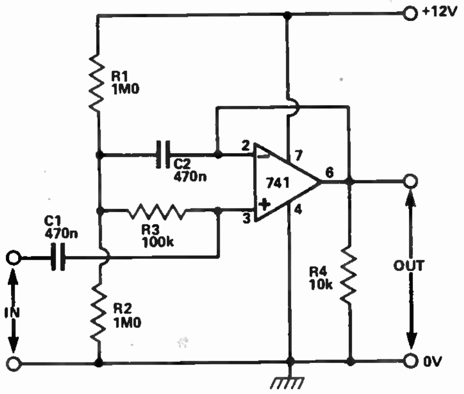


Fig.3 This single-supply version of the unity-gain non-inverting AC amplifier has an input impedance greater than 100M.

signal is AC-coupled to the op-amp side of R3 while the other side of this resistor is bootstrapped (via C2) from the output of the op-amp. The gain of the op-amp is so close to unity that the apparent (AC) impedance of R3 is increased to near-infinity, giving the circuit a true AC input impedance in excess of 100M. Without bootstrapping, the input impedance would be a mere 600k.

Note at this point that the attainable input impedance of the bootstrapped op-amp circuit is so high that in practice the true impedance is actually determined by the surface leakage impedance of the PCB and IC socket, etc. An easy way around this problem is to provide the area of the PCB surrounding the op-amp input pin with a 'guard ring', as shown in Fig. 4. This guard ring effectively bootstraps the leakage impedances of the PCB and raises them to near-infinite levels.

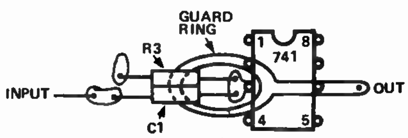


Fig.4 Method of providing a guard ring on the PCB, around the op-amp input terminal of the Fig.3 circuit, so that the PCB leakage impedances are effectively bootstrapped.

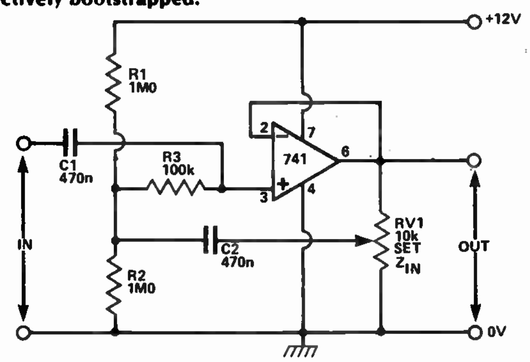


Fig.5 A variable input impedance unity-gain non-inverting AC amplifier. The impedance can be varied from 100k to 100M using RV1.

Figure 5 shows how the Fig. 3 circuit can be modified so that it acts as a variable-input-impedance circuit in which the impedance can be varied from roughly 100k to 100M using RV1. With RV1 slider set to the top of the pot, 100% bootstrapping is applied and the input impedance is 100M. With RV1 slider set to the bottom of the pot, zero bootstrapping is applied and R2 is bypassed to ground via C2, so the input impedance is about 100k.

Figure 6 shows how to bootstrap the unity-gain non-inverting op-amp circuit when operating it from split supplies. R1-R2 are the DC bias resistors, with R1 bootstrapped from the op-amp output via C2. The circuit has an input impedance capability of about 500M.

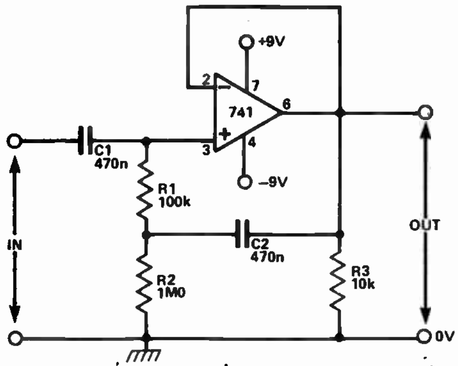


Fig.6 This bootstrapped split-supply unity-gain amplifier has an input impedance of about 500M.

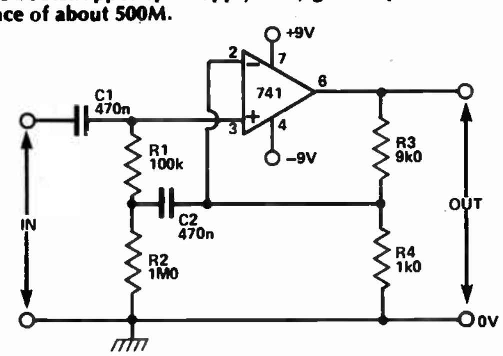


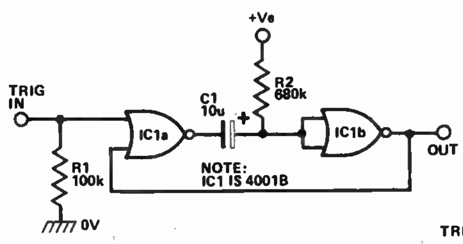
Fig.7 A high input impedance, x 10 non-inverting AC amplifier. Note that the guard ring of this circuit (if used) should be taken from across R4 (not from the op-amp output).

Finally, Fig. 7 shows how to apply the bootstrapping technique to a non-inverting amplifier with a gain greater than unity. Here, the gain is determined by the R3-R4 values and equals 10 with the values shown. Note that the bootstrapping signal is taken from the output of R4, rather than directly from the op-amp output. Also note that if a guard ring is used on the PCB, it must be bootstrapped from the same source.

Modified Monos

Now for a complete change of topic. If you've ever used the 4001B or 4011B CMOS ICs in the standard monostable configuration you'll know just how useful these circuits are in non-precision applications. They are easy to trigger, give clean outputs, and can cover a very wide timing range. The only trouble is, they're non-resettable; once they've been triggered they simply latch on until their timing periods end naturally. Figures 8 and 9 show a couple of easy ways of modifying these circuits to give easy reset operation.

Figure 8a shows the circuit of the conventional 4001B version of the standard monostable: with the R2 value shown, the circuit gives a timing period of about 0.5 s per microfarad of C1 value. The circuit is triggered by a positive-going input signal and generates a positive output waveform which is direct-coupled back to one input of IC1a to effectively maintain a 'trigger' input once the true trigger signal is removed.



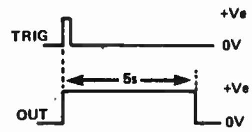


Fig.8a Standard 4001B monostable with a 5 s timing period.

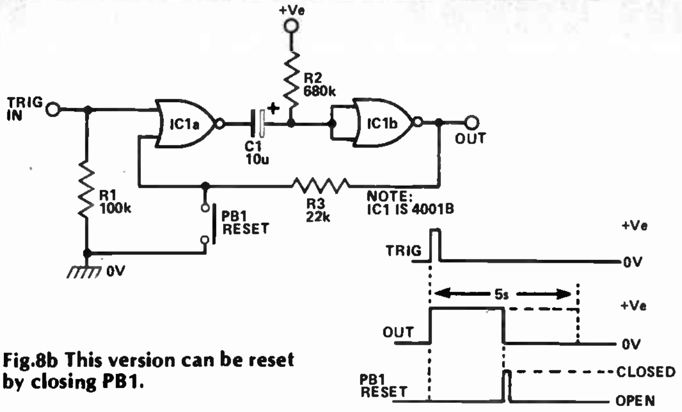


Fig.8b This version can be reset by closing PB1.

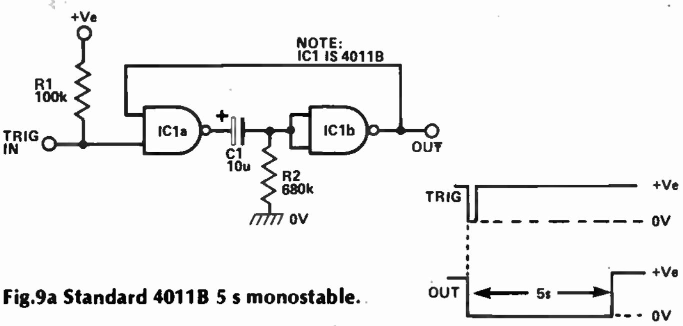


Fig.9a Standard 4011B 5 s monostable.

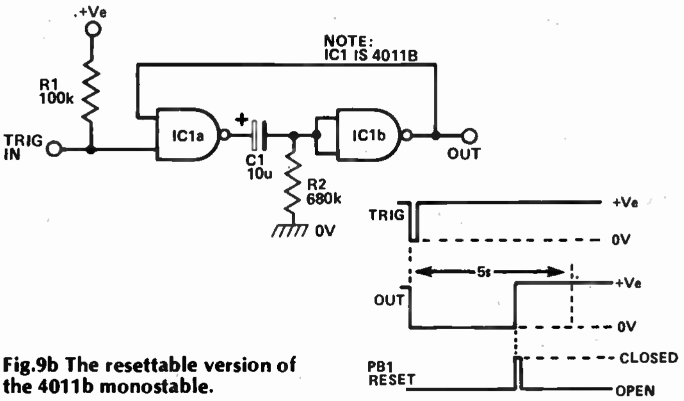


Fig.9b The resettable version of the 4011b monostable.

Figure 8b shows how the above circuit can be modified to give resettable operation. Here, the feedback connection from the IC1b output to the IC1a input is made via R3. Consequently, once the circuit has been triggered *and the original trigger signal has been removed*, the circuit can be reset at any time by simply pulling the feedback input of IC1a to ground. In the diagram we've shown this reset function accomplished using a simple push-button switch, but in practice it can be done using a gated transistor or CMOS switch, for example.

Figure 9 shows the 4011B version of the monostable unit, with the standard design in (a) and the resettable version in (b). Note here that the circuit is triggered by a negative-going input pulse and generates a negative or low output waveform.

New-fangled Flip-flops

Finally, to complete this edition of Notebook, Figs. 10 and 11 show a couple of unusual CMOS bistable circuits, each capable of being built using simple CMOS inverters or inverter-connected 4001B or 4011B gates. You'll sometimes find in project design that at some stage you'll have a couple of 'spare' 4001B or 4011B gates in a circuit, and at the same time need to use a simple bistable in the design, only to find that the spare gates are not compatible with the kind of bistable operation that is needed. The conventional 4001B bistable, for example, needs positive set and reset pulses, while the 4011B bistable needs negative set and reset pulses. The Fig. 10 or 11 circuits may solve your problems in such cases.

The operation of Fig. 10 circuit is pretty simple. Normally, the input of IC1a is held low by R1, the output of IC1a and the input of IC1b are high, the output of IC1b is low, and the circuit is in a stable state. If a positive 'set' pulse is momentarily applied across R1, the output of IC1b flips high and D1 then pulls the direct input of IC1a high and latches the circuit into this state, irrespective of subsequent actions of the set signal. The circuit can be reset by momentarily applying a positive pulse to the input of D2, thereby driving the output of IC1b low and latching the circuit back into its original state. Note that this circuit is triggered (set and reset) by positive-going input signals.

Figure 11 shows an alternative version of the bistable circuit, which in this case is triggered by negative-going inputs. The circuit is similar to that of Fig. 10, except that the polarities of the two diodes are reversed and the input of IC1a is normally biased high by R1. Note that both of these circuits have two outputs, thus providing either type of output polarity.

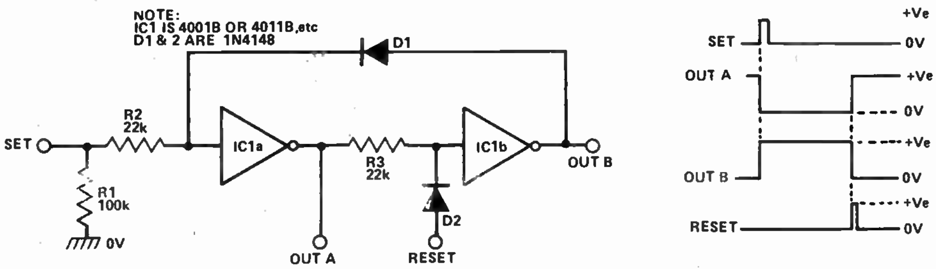


Fig.10 Positively-triggered bistable circuit.

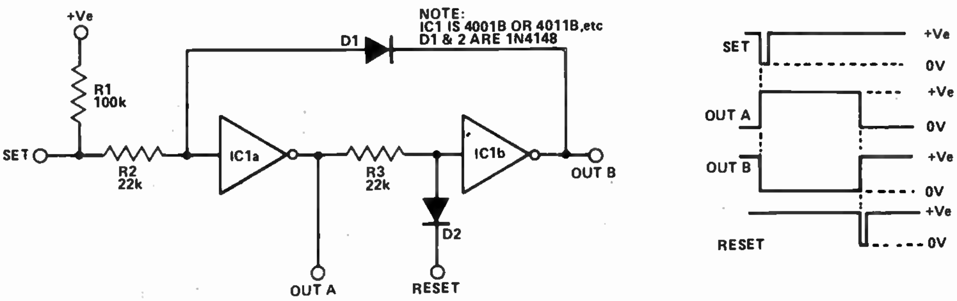


Fig.11 Negatively-triggered bistable circuit.

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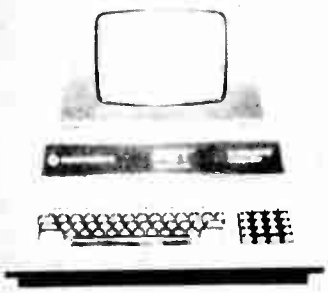

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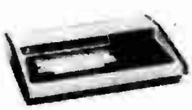

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HAND CLAP SYNTHESISER

Does your snare drum suffer from nervous skin tension, lack of timbre? Then revive it with the ETI Hand-clap Synthesiser. Designed to simulate the staccato effect of multiple hand-claps, the unit can be triggered by a microphone or footswitch. Design by Roger Shore. Development by Steve Ramsahadeo.

It would seem that no disco record is complete without the familiar hand-claps that faithfully accent the snare drum's down beat. One can imagine a group of people centred around a studio microphone, palms reddening, acting like human metronomes. We are happy to report that such a form of torture is now unnecessary in this electronic age!

It's generally accepted that the advent of the synthesiser in the late 60s was the commercial starting point of electronic music, not so much in the way of percussive synthesis but with such effects as tremolo, fuzz, flanging, reverberation and phasing, all of which are added to give expression to a piece of music.

Synthetic Control

The reproduction of synthetic voices, be it in digital or analogue form, requires precise control of all levels contributing to the original make-up of the sound. Musicians, producers and arrangers are continually striving for new creative sounds, and the pressure eventually falls on the engineer who is called upon to wave his magic wand and come up with the latest synthetic sound which will send the fans wild.

As in any new venture, whatever approach is used will be an expensive one. At present there are some systems commercially available. The Fairlight CMI (Computer Musical Instrument) is one, retailing at around £15,000 with its sophisticated electronics and hardware. It can create any musical sound you care to name. With such technology available creativity is limited only by the operator. However, if you prefer a dedicated instrument the LM1 Drum Computer can offer some interesting prospects. The unit is programmable, capable of accepting 100 drumbeats in real time, and there are real drum sounds — digital recordings stored in computer memory. Twelve percussive voices are provided (all tunable in pitch), there are facilities for versatile editing, a 'human' rhythm feel is made possible by special timing circuitry, and so the list goes on.

It is therefore not surprising that when designing the ETI Hand-clap Synthesiser some ground work was required.

No Applause Please

Multiple or 'ensemble' hand-clapping may be analysed subjectively in two distinct sections:

1. A general 'crash' — which may be simulated with a short burst of tuned noise.
2. Individual claps — this can be simulated by generating pulses which cause a multiple feedback band-pass filter to ring. Several different combinations of individual claps were

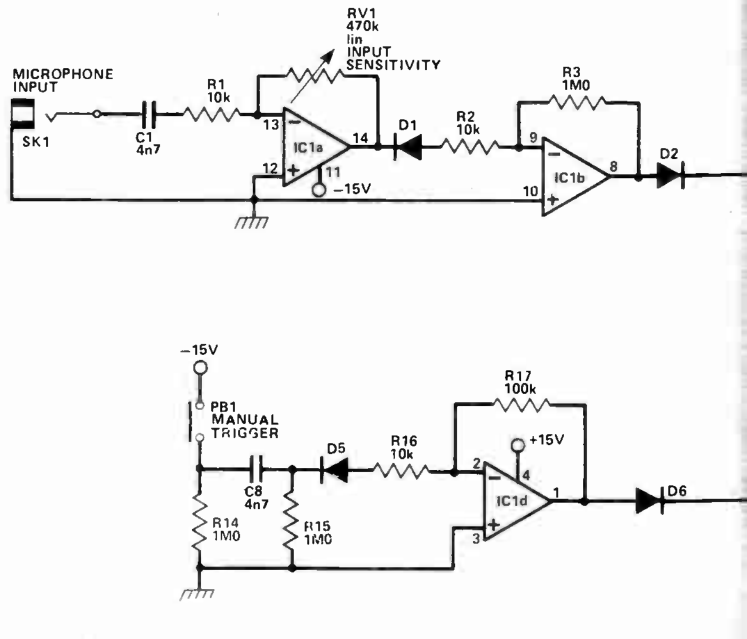


Fig.1 Circuit diagram of the Hand-clap Synthesiser.

tried from one to seven, at both regular and irregular intervals, but two provided the best subjective results.

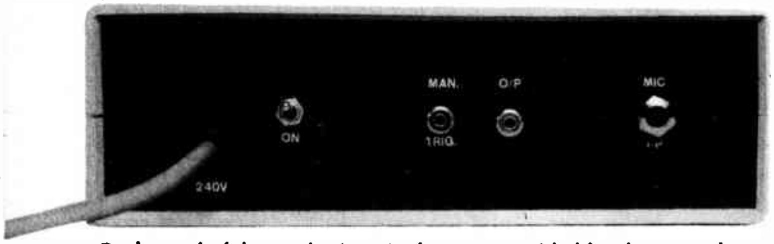
Setting up a unit such as this will depend on personal preferences and also on the type of amplifying system used. It is preferable to use a unit with reverberation where possible as this will greatly enhance the effect.

The problem of which variables should be external and which should remain preset is also one of personal taste. As circumstances dictate different settings we decide to make all seven controls external.

Construction

No problems should be encountered in constructing the Hand-clap Synthesiser. The power supply section should be built first; care should be taken to sleeve the mains terminals on the PCB and the on/off switch.

When this is completed, connect a voltmeter across the output pins of the supply. A reading of +15 V and −15 V should be available at the output. If all is well the rest of the control circuit can be constructed observing the usual CMOS handling procedure and the orientation of polarised components.



Back panel of the synthesiser. Sockets are provided for the manual trigger (an external footswitch) or a microphone, triggered by the snare drum for example.

HOW IT WORKS

The unit can be triggered from either a momentary push-button (PB1) or from a suitable transducer, eg a microphone placed near a snare drum.

In the first case, pressing PB1 causes a negative-going pulse to be developed across C8. This is steered via D5 to the inverting input of IC1d, causing a positive pulse to appear at the cathode of D6.

Alternatively, an input signal from a microphone is differentiated by C1 and R1. This prevents false triggering from other nearby sources. The signal is amplified and inverted by IC1a with RV1 acting as a sensitivity control. Further inversion by IC2b is required to provide a positive pulse at the cathode of D2. These trigger pulses appearing at the cathodes of D2 or D6 are fed to both the anode of D3 and pin 1 of IC2a.

When D3 is forward biased by the trigger pulse it allows C3 to charge positively. The rate of discharge is determined by R5 and the setting of RV2; this ramp is buffered by IC1c, the output of which is connected to D4 and C4 via R8.

The base-emitter junction of Q1 is reversed biased to produce the required noise. A low noise transistor is chosen to give a cleaner noise source. This noise is amplified by IC3a and fed to the cathode of D4. When a trigger pulse causes a positive ramp to appear at the output of IC1c, D4 conducts allowing noise to pass via D4 and C4 to the band-pass filter formed by IC3b and associated components. The length of this noise pulse is determined by the setting of RV2, the ramp discharge time.

R9 normally holds the anode of D4 at approximately −1V5 to prevent noise peaks from turning D4 on intermittently.

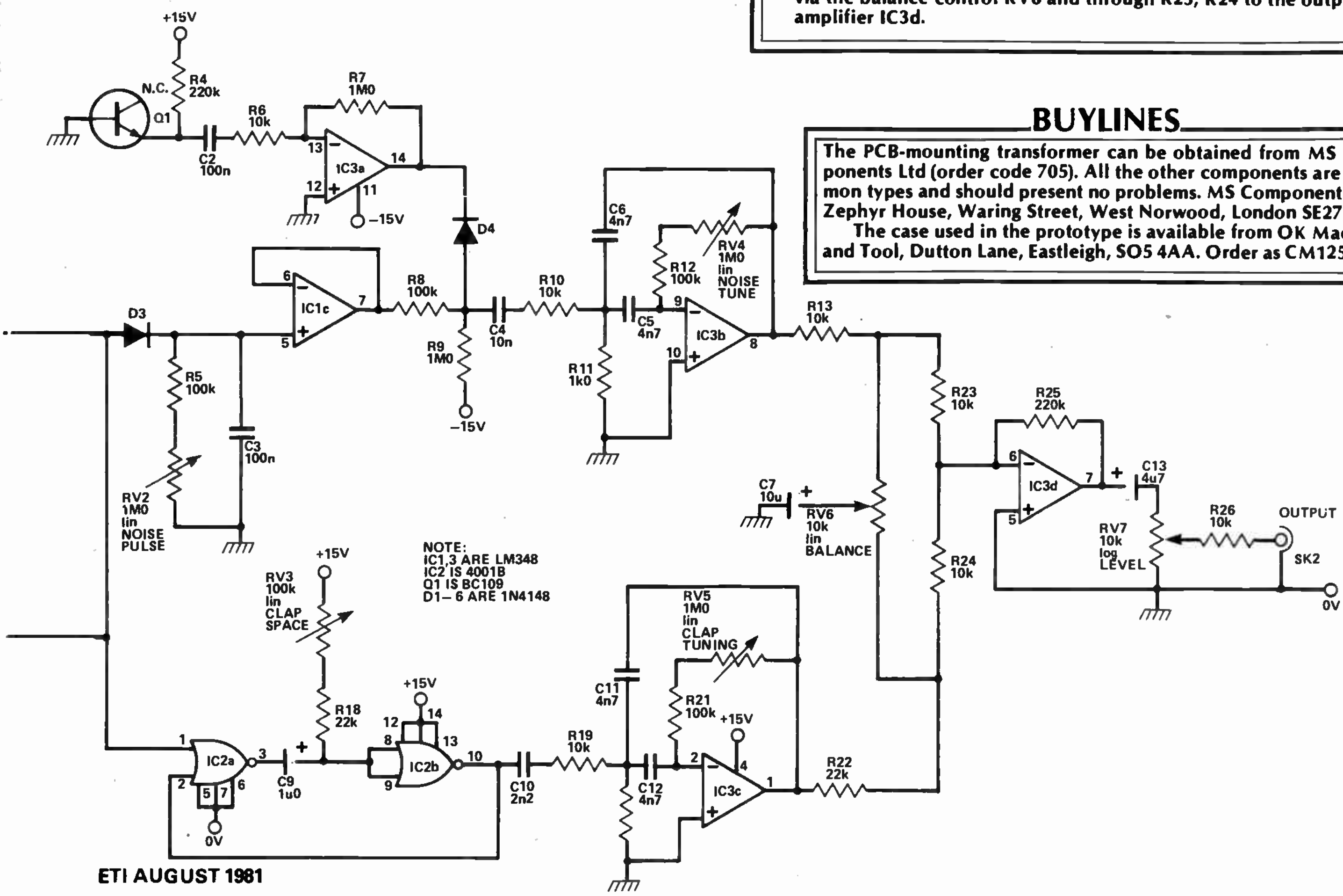
The band-pass filter is tuned over the 'useful' part of the noise spectrum for this application. Although the Q of the filter network will vary (because RV4 is not 'ganged' with R10), this does not pose any problem in this non-critical situation.

At the same time as the noise pulse is generated, the trigger pulse is applied to pin 1 of IC2a, turning on the monostable formed by IC2a and IC2b and allowing pin 10 to assume a high state. This positive voltage is developed across C10, causing the band-pass filter formed around IC3c to ring at a frequency determined by the position of RV5. (The two band-pass filters are of identical design.) At a time determined by RV3 and C9 the monostable will reset and the negative-going edge at pin 10 of IC2b allows a second ringing pulse to be generated by the band-pass filter. These two ringing pulses are the individual claps and are mixed with the noise pulse via the balance control RV6 and through R23, R24 to the output amplifier IC3d.

BUYLINES

The PCB-mounting transformer can be obtained from MS Components Ltd (order code 705). All the other components are common types and should present no problems. MS Components Ltd, Zephyr House, Waring Street, West Norwood, London SE27 9LH.

The case used in the prototype is available from OK Machine and Tool, Dutton Lane, Eastleigh, SO5 4AA. Order as CM125-225.



PARTS LIST

Resistors (all ¼ W, 5%)	
R1,2,6,10,13,16,19,23, 24,26	10k
R3,7,9,14,15	1M0
R4,25	220k
R5,8,12,17,21	100k
R11,20	1k0
R18,22	22k
R27	1k2
Potentiometers	
RV1	470k linear
RV2,4,5	1M0 linear
RV3	100k linear
RV6	10k linear
RV7	10k logarithmic
Capacitors	
C1,5,6,8,11,12	4n7 ceramic
C2,3	100n polycarbonate
C4	10n polycarbonate
C7,16,19	10u 35 V tantalum
C9	1u0 35 V tantalum
C10	2n2 ceramic
C13	4u7 35 V tantalum
C14,17	1000u 25 V axial electrolytic
C15,18	220n polycarbonate
Semiconductors	
IC1,3	LM348
IC2	4001B
IC4	78L15
IC5	79L15
Q1	BC109
BR1	50 V, 1 A bridge rectifier
D1-6	1N4148
LED1	0.125" red LED
Miscellaneous	
T1	15-0-15, 3 VA PCB-mounting transformer (see Buylines)
SW1	DPDT miniature toggle
PB1	momentary push-button
SK1	¼' jack socket
SK2	phono socket
FS1	50 mA fuse and holder
Case (see Buylines), seven collet knobs.	

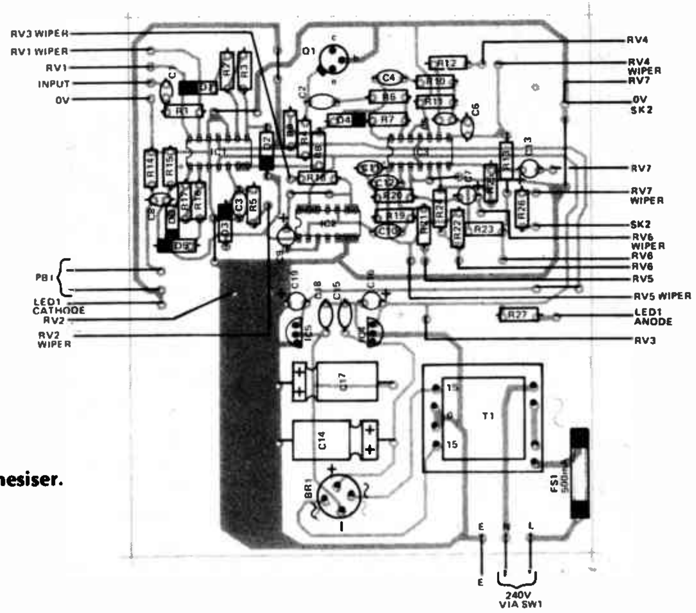


Fig.2 Component overlay for the Hand-clap Synthesiser.

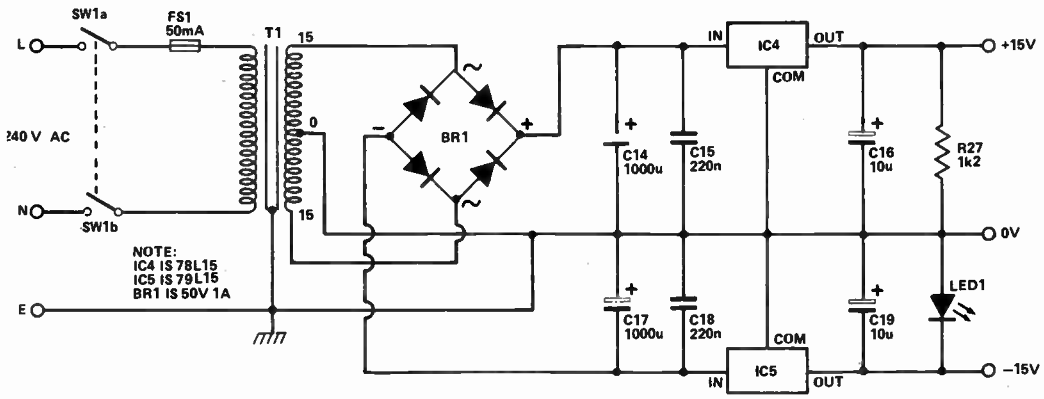
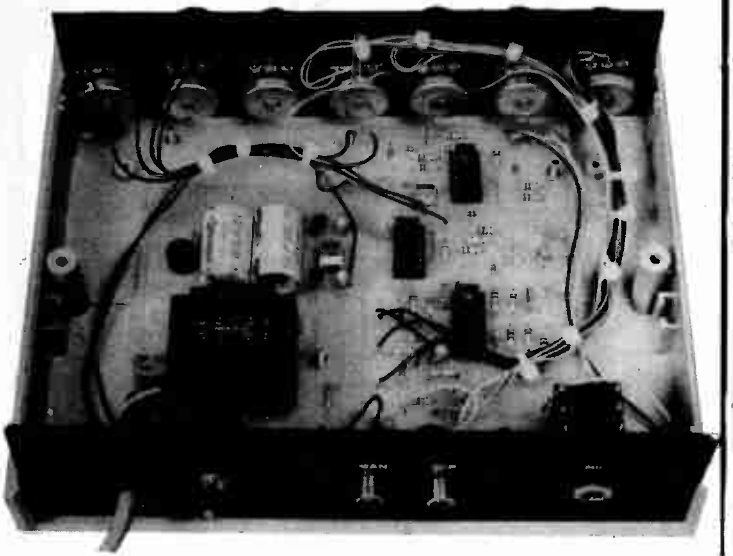
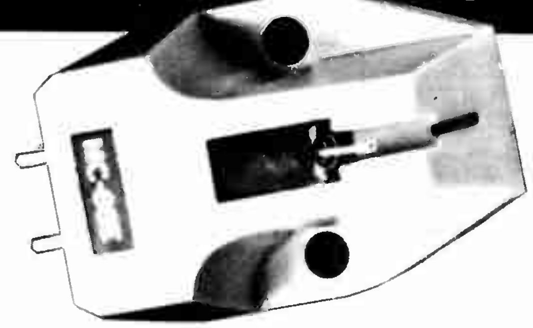


Fig.3 Circuit diagram of the power supply for the synthesiser.



The Hand-clap Synthesiser with the lid removed. The sockets and switch mount on the rear panel, and the potentiometers and LED on the front; all the other components, including the mains transformer, fit onto the single PCB, making construction extremely easy. Follow the overlay and this photograph when interwiring and position the wiring looms exactly as shown, in order to minimize hum and noise. Plastic cable ties will keep everything neat and tidy.

ETI



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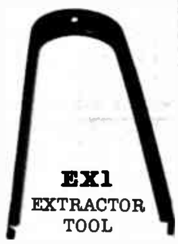

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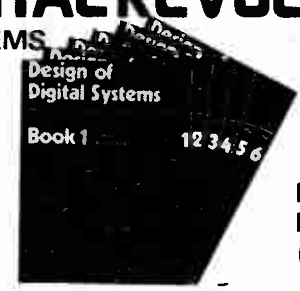

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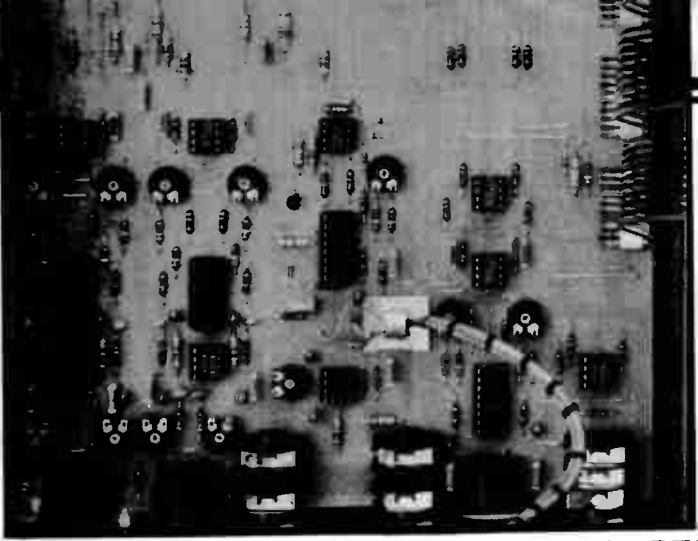


PROJECT

The input board. The input and output sockets are all PCB-mounting and connections to the panel board are made via multiway cable and a Molex connector.

BUYLINES

A complete set of parts for this project, including fully finished metalwork, nuts, bolts etc, will be available from Powertran Electronics for £97.50 plus VAT for the mixer and £9.90 plus VAT for the power supply, post free. For delivery by Securicor add £2.50 (VAT inclusive). Powertran also supply the separate parts for the mixer, eg metalwork set, PCB, semiconductors etc. Telephone Andover 64455 or write to Powertran Electronics, Portway Industrial Estate, Andover, Hants SP10 3NM.

PARTS LIST

Resistors (all ¼ W, 5%)

R1,12,32,34,52,53,99,117,142, 160,162,164,170,172,176	47k
R2,13,33,35,69	1k0
R3,5,14,16,29,30,36,38,87,152	1M0
R4,15,31,37,51,54,89,97,143, 179,180,182,188,189,191,199, 206	100k
R6,17,28,39,50,55,144	5k6
R7,8,18,19,26,27,40,41,48, 49,56,57,145,147	390R
R9,11,20,22,23,25,42,44,45,47, 58,60,61,62,67,98,101,106,107, 108,109,110,111,112,113,114, 115,119,124,125,126,127,128, 129,130,131,132,134,146,148, 158,165,166,171,202,203	10k
R10,21,24,43,46,59	6k8
R63,71,81	1k3
R64,65,72,73,79,80	1k8
R66,70,82,95	68k
R68	2k0
R74,83	8k2
R75	130k
R76	39k
R77	36k
R78	1k2
R84,175	2M2
R85,86	10M
R88,92,93,94,100,102,105,116, 118,120,123,135,163	150k
R90	820R
R91,181,183,190,192	200k
R96	560k
R103,104,121,122,154,156, 169,174	18k
R136,139,149,177	22k
R137,138,140	27k
R141,173	1k5
R150,184,193	2k2
R151,153	330k
R155,197,204	220k
R157	180R
R159,178,185,194	4k7
R161	470k
R167	12k
R168	33k
R186,195,198,205	3k3
R187,196	47R
R200,207	2R7
R201,208	15R

Note that R133 is not used

Potentiometers

RV1	100k dual antilogarithmic rotary
RV2	10k logarithmic rotary
RV3	10k linear rotary
RV4	10k dual linear rotary
RV5	10k logarithmic slider
RV6,7,8,9,10	100k dual linear slider
RV11	47k dual logarithmic slider
RV12,13	47k logarithmic slider
PR1,3,5,7	1k0 miniature horizontal preset
PR2,4,6,8,10,11,12	220R miniature horizontal preset
PR9	470k miniature horizontal preset
PR13	4k7 miniature horizontal preset
PR14,15	22k miniature horizontal preset

Capacitors

C1,8,21,22	47p ceramic
C2,9,20,23,29,30,40,111,112	10u 16 V tantalum
C3,10,19,24	3n3 polycarbonate
C4,11,18,25	680p ceramic
C5,12,17,26,31,34,37,38,39,41, 55,80,82,92,95,100,103,105	100n polycarbonate
C6,13,16,27,32,35,75,76,78,81, 89,90	1u0 35 V tantalum
C7,14,15,28,33,36,50,51,64,65	1n0 polycarbonate
C42,56,87,88	15n polycarbonate
C43,45,57,59	680n polycarbonate
C44,47,58,61,84,85,86	150n polycarbonate
C46,60	33n polycarbonate
C48,52,62,66	8n2 polycarbonate
C49,63	39n polycarbonate
C53,67	470p ceramic
C54,68	2n2 polycarbonate
C69	2u2 16 V tantalum
C70,91,93,96	470n 35 V tantalum
C71,73	220n polycarbonate
C72,74	100p ceramic
C77,99,106	4u7 16 V tantalum
C79,83	4n7 polycarbonate
C94,97,101,102,104,107	220u 16 V electrolytic, PCB type
C98,108	22n polycarbonate
C109,110	2200u 25 V axial electrolytic
C113,114	47n 50 V disc ceramic

Semiconductors

IC1,3,4,6,7,11,12,13,18,19,20, 21,22,23,24,25,26	RC4558
IC2,5,8,10	LM13600
IC9,15,27	741
IC14,16,17,28,31,33	1458
IC29	TL081 or equivalent
IC30	LM1877N-9
IC32,34	LM3915
IC35	7812
IC36	7912
Q1-7	BC212L
Q8	BC182L
D1-24	1N4148
D25-28	1N4002
ZD1	6V2 400 mW
LED1-3,5-13,15-23	0.2" red LEDs
LED4,14	0.2" green LEDs

Miscellaneous

SW1,2,5,6	DPDT slide switch
SW3	four-pole three-way rotary switch
SW4	SPDT toggle switch
SW7	three-pole four-way rotary switch
SW8	push-to-make non-locking switch
SK1,2,5	five-pin DIN sockets (PCB type)
SK3,4	¼" mono jack socket (PCB type)
SK6	¼" stereo jack socket (PCB type)
SK7	¼" stereo jack socket

Transformer (15-0-15 @ 300 mA), fuse (500 mA), fuseholder, mains lead, cabinet, knobs to suit, eight-pin DIL sockets (27 off), 16-pin DIL sockets, (four off), 14-pin DIL socket (one off), 18-pin DIL sockets (two off), flexible multiway cable and Molex PCB plugs, mounting hardware to suit.

➔

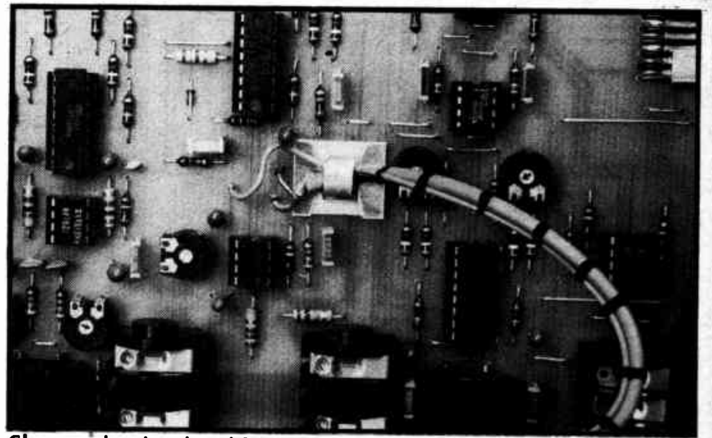
is controlled by a five section graphic equaliser with two octave spacing as well as a special beat lift device. A voice-over unit (ducking) has been included as well as an override function for interrupt announcements. The microphone input can also be modulated, at a variable rate, to produce growl effects. A monitor section with a stereo headphone output allows the operator to listen (pre-fade listen) to any of the music inputs. The level of the selected signal path is displayed on an LED PPM.

Voltage controlled amplifiers have been used to control the signal levels in all seven audio paths. They have the ability to produce automatic cross-fades and ducking, as well as reducing crosstalk. The signal is not transmitted anywhere until the control voltage is correct. Therefore it will not crosstalk until it has been faded up, and then it doesn't matter.

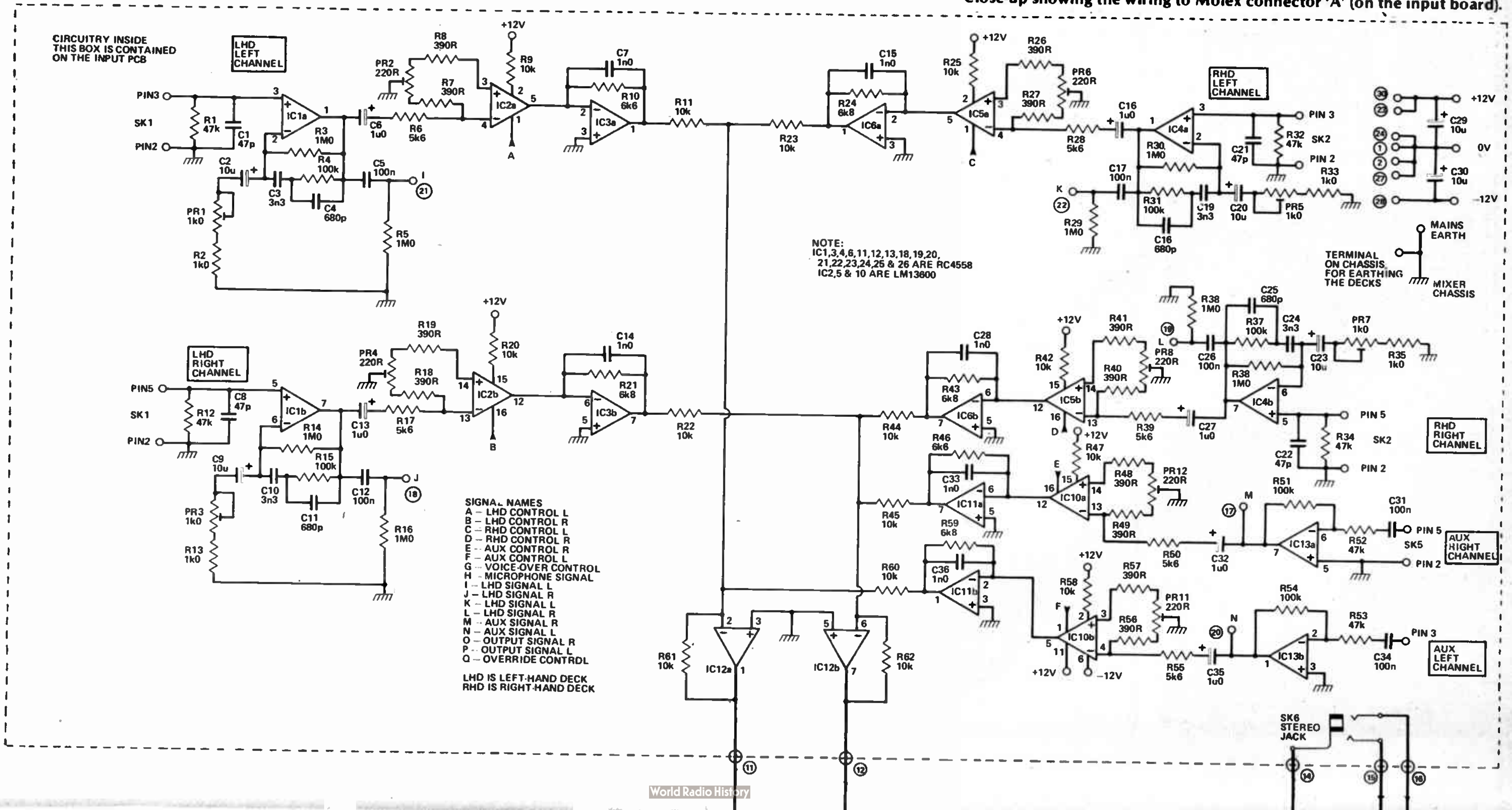
TABLE 1.

Noise chart for converting dBm into voltage.

0 dBm	775 mV_{RMS}
−10 dBm	245 mV_{RMS}
−20 dBm	77.5 mV_{RMS}
−30 dBm	24.5 mV_{RMS}
−40 dBm	7.75 mV_{RMS}
−50 dBm	2.45 mV_{RMS}
−60 dBm	77.5 uV_{RMS}
−70 dBm	245 uV_{RMS}
−80 dBm	77.5 uV_{RMS}
−90 dBm	24.5 uV_{RMS}
−100 dBm	7.75 uV_{RMS}
−110 dBm	2.45 uV_{RMS}



Close-up showing the wiring to Molex connector 'A' (on the input board).



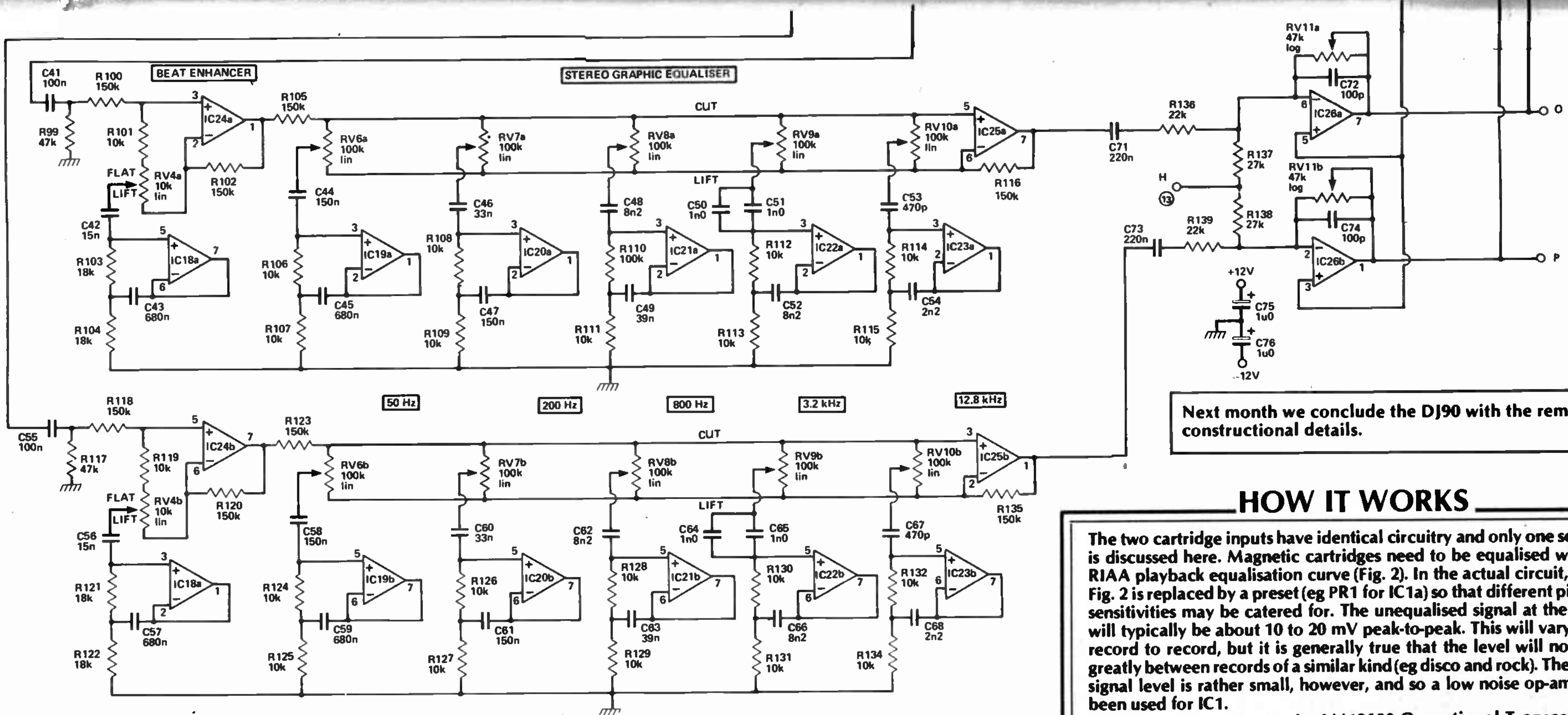
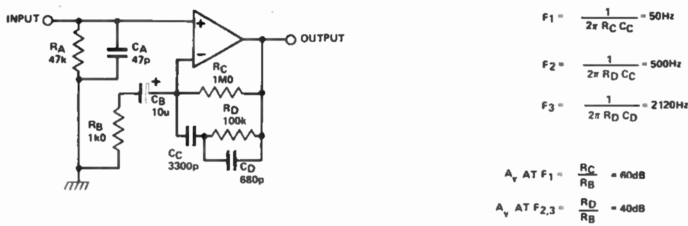


Fig.1 Circuit diagram for the music input and graphic equaliser sections.

Next month we conclude the DJ90 with the remaining constructional details.



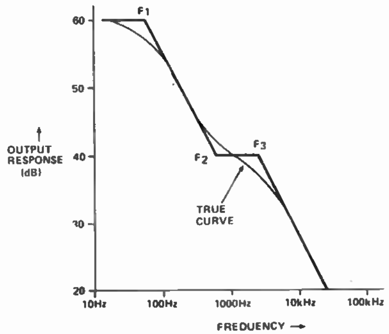


Fig.2 The RIAA equalisation block and the associated equations. The graph shows the frequency response.

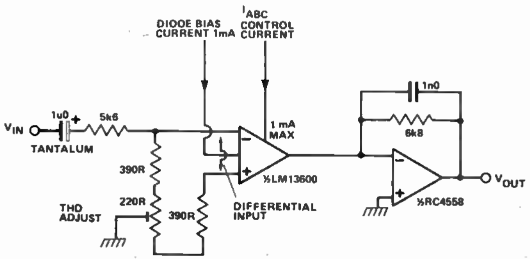


Fig.3 The basic VCA unit and a table showing the performance figures (see text).

TYPICAL MEASUREMENTS

MEASUREMENTS TAKEN OVER A 20 kHz BANDWIDTH AT 100 Hz, 1 kHz AND 10 kHz. I_{ABC} SET AT 1 mA. THE PRESET IS SET TO THE BEST THD POSITION.

V_{IN} dBm	V_{IN} Vpp	DIFFERENTIAL INPUT mVpp	OUTPUT THD%	OUTPUT S/N RATIO
+12dBm	8V8	80mV	0.8%	92.5dB
+6dBm	4V4	40mV	0.2%	86.5dB
0dBm	2V2	20mV	0.055%	80.5dB
-6dBm	1V1	10mV	0.04%	74.5dB
-12dBm	0V55	5mV	0.02%	68.5dB

HOW IT WORKS

The two cartridge inputs have identical circuitry and only one section is discussed here. Magnetic cartridges need to be equalised with an RIAA playback equalisation curve (Fig. 2). In the actual circuit, R_B of Fig. 2 is replaced by a preset (eg PR1 for IC1a) so that different pick-up sensitivities may be catered for. The unequalised signal at the input will typically be about 10 to 20 mV peak-to-peak. This will vary from record to record, but it is generally true that the level will not vary greatly between records of a similar kind (eg disco and rock). The input signal level is rather small, however, and so a low noise op-amp has been used for IC1.

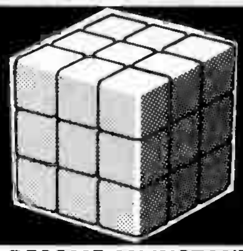
The VCA unit uses the LM13600 Operational Transconductance Amplifier; in the actual circuit this section comprises IC2 and IC3. The gain of the unit depends on the control current I_{ABC}, so the unit should actually be called a current controlled amplifier (ICA); however, we shall stick to the misnomer of VCA. The LM13600 has a diode predistortion network included in the IC which actually reduces the THD of the unit by as much as 10 dB. It was decided to operate the VCA at a V_{IN} level of 0 dBm (2V2 peak-to-peak). This gives a THD of 0.055% (typical best) and a signal-to-noise ratio of 80.5 dB. It also gives an overhead of about 18 dB. The output noise at 0 dBm is well below that of the RIAA stage and so it can be ignored.

The AUX input uses the same VCA (IC10, 11), but it does not have an RIAA circuit. Instead it has a +6 dB gain, flat frequency response preamplifier, built around IC13.

All three music inputs are mixed together by IC12 and fed into the beat lift and graphic equaliser section. The beat lift circuit is a peaky 90 Hz resonator, designed around IC18 and IC24, that can provide a variable lift. This tends to emphasise the beat in the music. The graphic equaliser (ICs 19 to 23 and IC25) uses the same circuit as the beat lift except that it can provide both lift and cut.

The circuit operates as follows. Each section (IC19a, C44, R106, R107, C45, for example) is a fixed frequency resonator. At resonance the resonator looks like a short to the ground. By connecting this resonator to the wiper of a pot which is connected across the input and the feedback of an amplifier, the amplifier can be made to provide cut and lift respectively at the resonant frequency. The resonator selectively shorts out the input signal or the feedback signal. The output of the equaliser is fed into a variable gain mixer, IC26, together with the output from the microphone section. Throughout the system, the operating signal level is 0 dBm, although gain can be provided in the equaliser. The output is also capable of generating 6 dB of gain.

ETI



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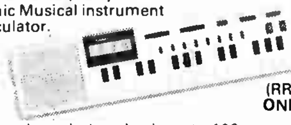

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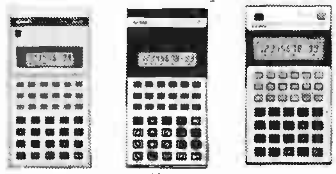

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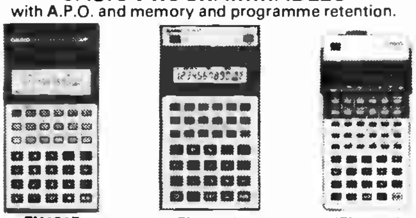

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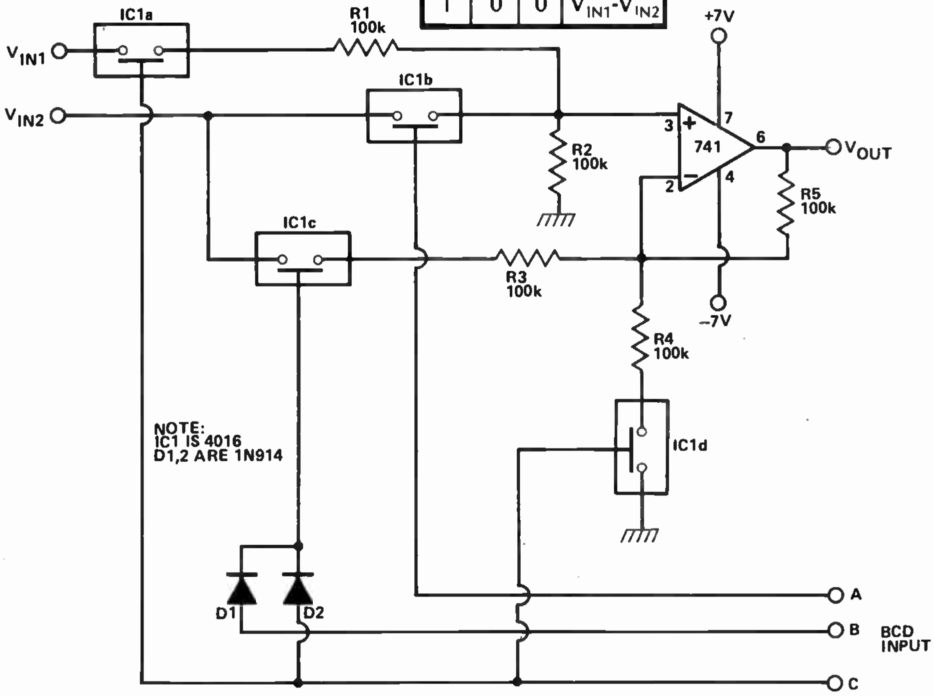
TECH TIPS

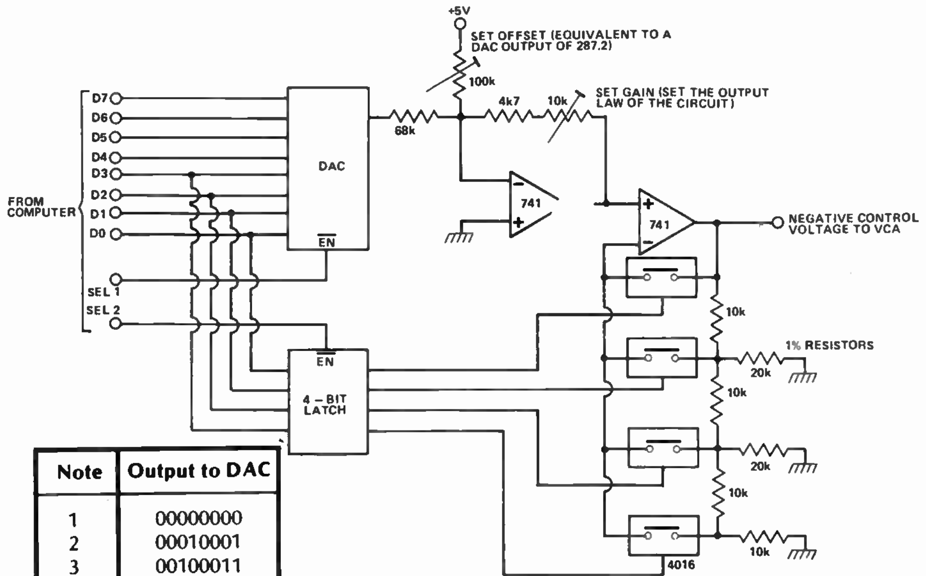
Programmable Op-amp

J. P. Macauley, Crawley

This circuit was developed for experimental purposes and enables an op-amp to be operated in either the inverting, non-inverting or differential mode. This is accomplished by switching inputs into the circuit by means of IC1, a quad bilateral CMOS transmission gate. A diode matrix connects the control voltage for the gates together so that the operating mode can be controlled by a simple BCD-encoded word. As presented here the gain of the op-amp is unity, although this can be altered by the simple expedient of altering the respective resistor values. Note, however, that the output may distort if resistor values of less than 10k are used. This is due to the transmission gates, which like to 'see' at least this resistance as a load.

C	B	A	V_{OUT}
0	0	1	V_{IN2}
0	1	0	$-V_{IN2}$
1	0	0	$V_{IN1}-V_{IN2}$





Computer-controlled Synthesiser Keyboard

K. Wood, Ipswich

Referring to P. McChesney's idea published in Tech Tips, May '81 issue, it is possible to obtain an output voltage of an accuracy similar to that of the 12 bit code given without resorting to a second digital-to-analogue converter.

The logarithmic property of music allows this to be done. For each octave higher a note is, its frequency (and hence the control voltage of a linear oscillator), must double. Thus it is possible to generate voltages for the top octave of a keyboard, and obtain control voltages for lower octaves by dividing it by two, four, eight and so on, according to the number of octaves required.

An alternative arrangement is outlined to cope with these ideas. The note is output to the DAC, and its octave number is sent separately to the divider network by the computer system. A bias is added to the voltage to eliminate another bit from the 12 bit code, reducing it to the eight bit capability of the DAC.

Note	Output to DAC
1	00000000
2	00010001
3	00100011
4	00110110
5	01001011
6	01100000
7	01110111
8	10001111
9	10101001
10	11000010
11	11011110
12	11111111

Octave	Output to Latch
1	00000001
2	00000010
3	00000100
4	00001000

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LED Peak Meter

G. Durant, Selby

This circuit gives a bar display when connected to an audio source, such as the speaker outputs of an amplifier. Each channel is fed to one of the drivers IC1a, IC1b, which are op-amps wired as peak voltage detectors; they also rectify the signal and give the output voltage the characteristic PPM fast attack and slow (1 s) decay times.

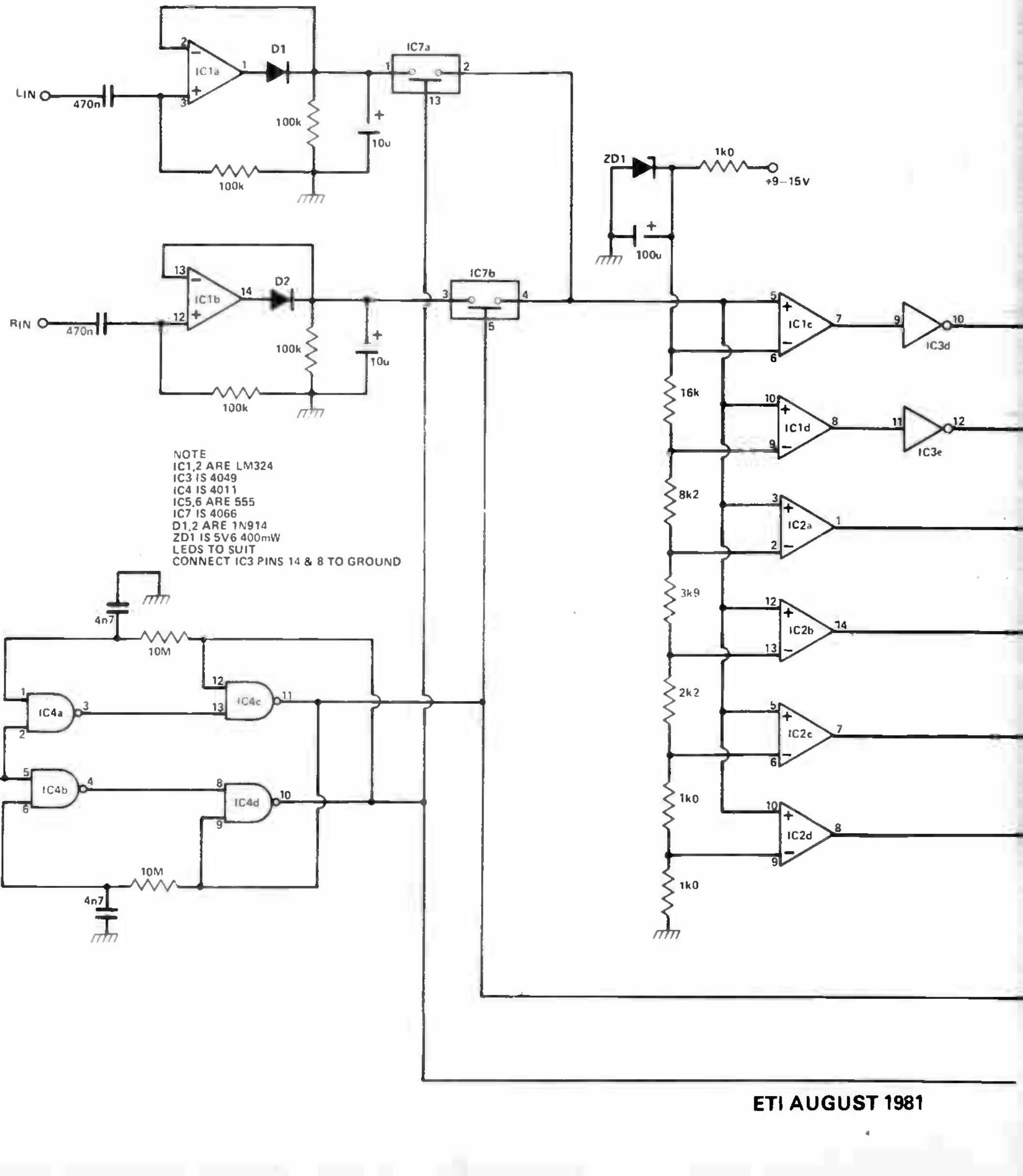
The display section is multiplexed for low cost. A row of comparators (IC1c-IC2d) have their inverting terminals held at a particular voltage by a resistor chain and a reference voltage derived from a zener diode. The audio signal is fed to the non-inverting terminals of the comparators and as it reaches the reference level on each inverting input, the corresponding output goes high.

The output of each comparator is taken to two LEDs via a current-limiting resistor. Two independent displays are formed by taking the cathodes of each pair of LEDs to one of two common lines; each line can be connected to ground by one of the switches IC7c, IC7d. The two remaining switches in IC7 select which channel is to be sampled by the comparator section.

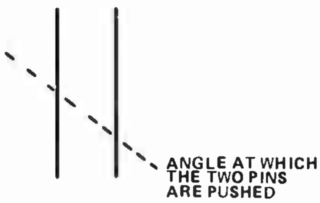
A clock formed by IC3a,b,c and running at about 100 Hz feeds a retriggerable flip-flop built around IC4. The two outputs control the IC7 switches so that each channel is measured and displayed on the appropriate LEDs in alternation.

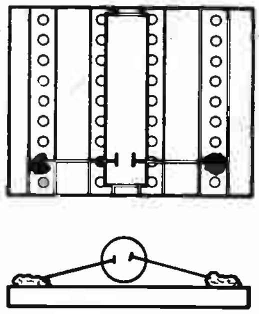
A brief peak which reaches the top two LEDs on each channel may be too short to notice. When the top two comparators are triggered, they activate the peak hold circuitry built around IC5 and IC6. These are 555 timers wired in the astable mode and prolong the time for which the LEDs are illuminated to about 600 ms and 1.2 s respectively. This gives the same impression as a commercial peak hold meter.

The circuit requires a single 15 V supply, and use can be made of the existing supply when the circuit is built into the equipment. The LEDs, which can be rectangular if preferred, are mounted in two rows of six and labelled with the level in dB (which is only approximate). The number of display LEDs can be extended by adding more resistors and comparators to the existing chain.

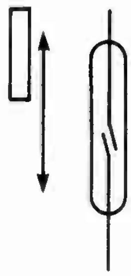


Below and right: Constructing a cheap tilt switch.





Below: 'Magnetic' tilt switch.

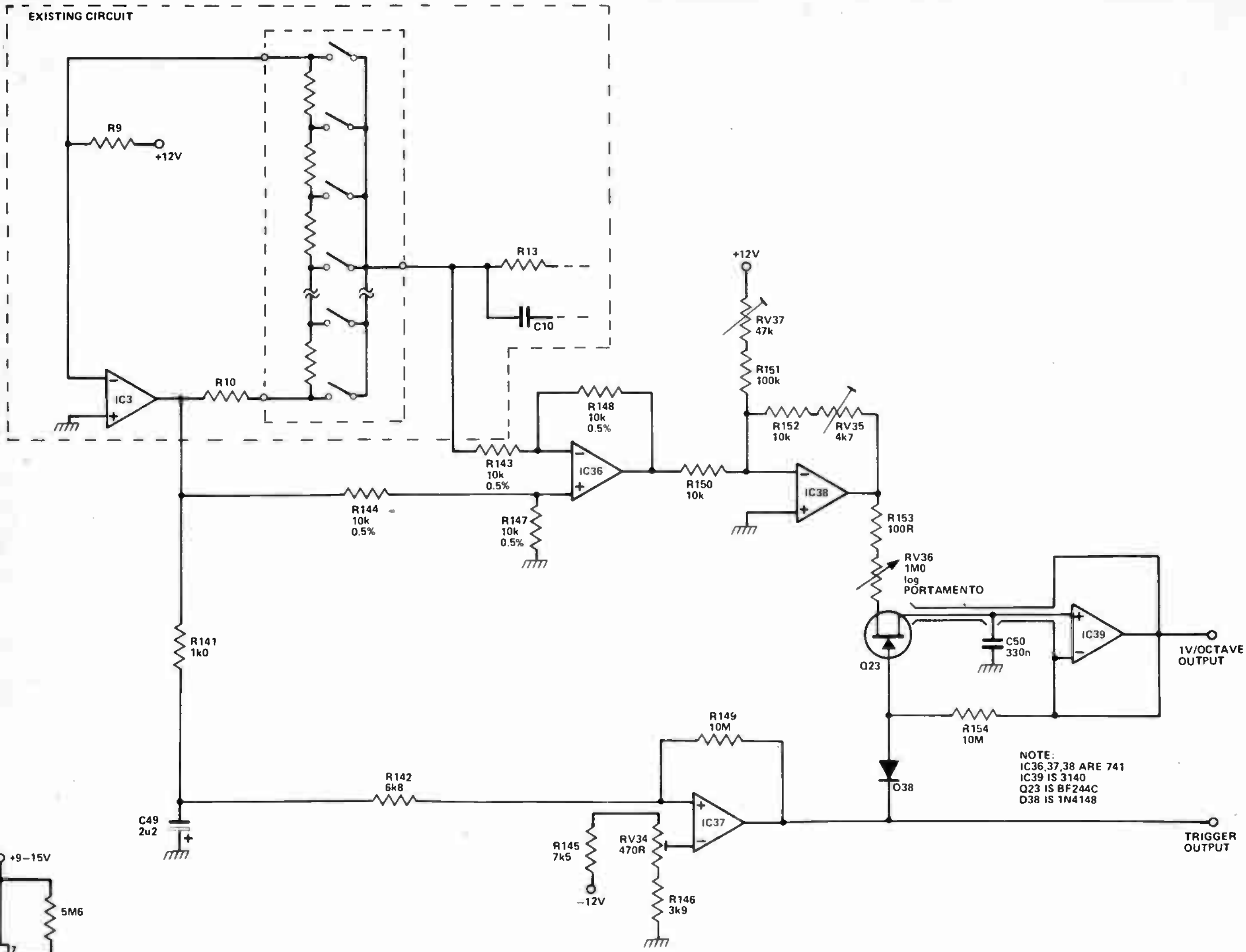


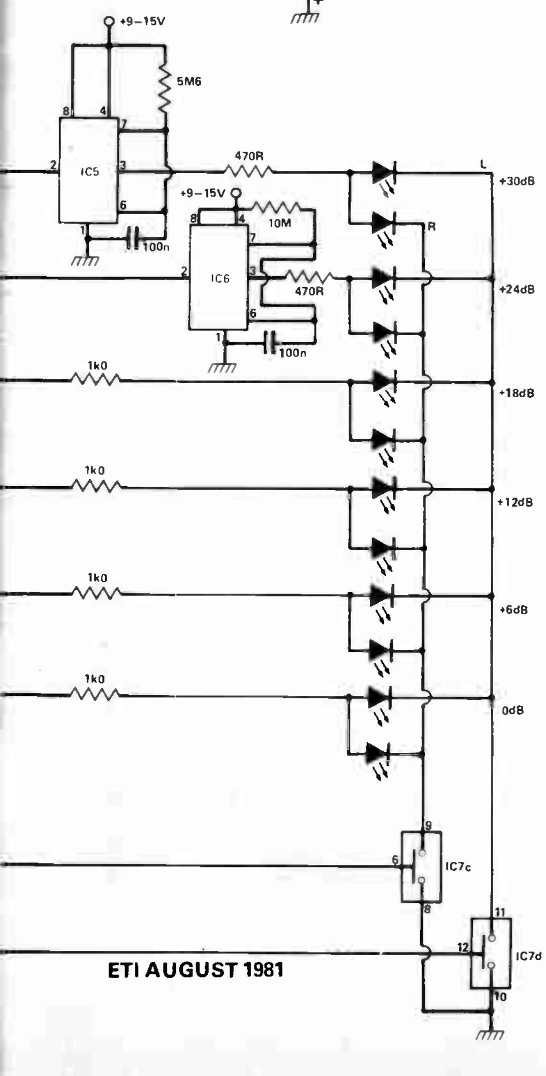
Cheap Tilt Switch

M. J. Woodbridge, St. Albans

The ETI Musical Box needs a mercury tilt switch, but there are cheaper ways of providing one. One way is to use a plastic biro refill end about 1.5-2 cm long. Thick pins are pushed into the soft plastic tube at one end as shown, at 180° to one another. The pins are then bent down at right angles to the tube and soldered to a small piece of Veroboard. The end of the tube nearest the pins is blocked up using glue, or by melting the plastic with a hot object. A small ball bearing is inserted, which will short the pins when it touches them. Blocking up the other end of the tube leaves you with a passable tilt switch.

A second way of making a tilt switch is to have a magnet moving up and down in a plastic channel near a reed switch.





Duophonic Synthesiser Keyboard

P.R. Williams, Stevenage

Most synthesisers, including the otherwise excellent ETI Transcendent 2000, are strictly monophonic; only one note can be keyed at a time. True polyphonic synthesisers are, however, complex and expensive. The circuit described here is a very simple modification which can be made to the Transcendent 2000 to make it a duophonic instrument; that is, any two keys can be pressed simultaneously to produce two notes.

The circuit relies on the fact that the keyboard resistor chain is fed by a constant current source, IC3. When more than one key is pressed, one or more resistors in the chain are short-circuited, resulting in the output of IC3 becoming more positive to keep the current constant. The output voltage of the normal keyboard circuit is then equal to that corresponding to the highest note pressed. The change in voltage at IC3's output is thus proportional to the number of keys between the highest and lowest pressed.

Thus, to obtain the voltage corresponding to the lowest key pressed, the change in voltage at IC3's output must be subtracted from the normal keyboard voltage. This is done at IC36. IC38 provides a scaling factor to achieve the common 1 V/octave output, which is adjustable by RV35. An offset is also introduced at this point to put the voltage in a useful range. RV37 controls this.

A trigger signal derived from the change in IC3's output is produced by the level detector, IC37. R141 and C49 de-bounce the contacts, while R142 and R149 provide some hysteresis for additional triggering reliability. RV34 is set so that IC37 will reliably detect when two or more keys are simultaneously pressed. Q23 and IC39 form a sample and hold circuit, which has been duplicated from the Transcendent 2000 design. RV36 could be ganged with the existing portamento control.

The output can then be used to control either an external VCO or another synthesiser.

Although this circuit was primarily designed as a modification to the Transcendent 2000, it could be easily adapted for use with any synthesiser that uses a constant current keyboard resistor chain.

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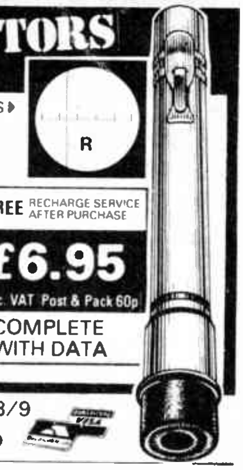

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	1X011	9 + 9	1.66	
	1X012	12 + 12	1.25	
	1X013	15 + 15	1.00	
	1X014	18 + 18	0.83	
	1X015	22 + 22	0.68	
	1X016	25 + 25	0.60	
	1X017	30 + 30	0.50	
50va 80 × 35mm 0.9 Kg regulation 13%	2X010	6 + 6	4.16	£4.93 + £1.10 P&P + 0.90 V.A.T.
	2X011	9 + 9	2.77	
	2X012	12 + 12	2.08	
	2X013	15 + 15	1.66	
	2X014	18 + 18	1.38	
	2X015	22 + 22	1.13	
	2X016	25 + 25	1.00	
	2X017	30 + 30	0.83	
	2X028	110	0.45	
	2X029	220	0.22	
	2X030	240	0.20	
80va 90 × 30mm 1 Kg regulation 12%	3X010	6 + 6	6.64	£5.47 + £1.43 P&P + 1.04 V.A.T.
	3X011	9 + 9	4.44	
	3X012	12 + 12	3.33	
	3X013	15 + 15	2.66	
	3X014	18 + 18	2.22	
	3X015	22 + 22	1.81	
	3X016	25 + 25	1.60	
	3X017	30 + 30	1.33	
	3X028	110	0.72	
	3X029	220	0.36	
	3X030	240	0.33	
120va 90 × 40mm 1.2 Kg regulation 11%	4X010	6 + 6	10.00	£6.38 + £1.43 P&P + £1.17 V.A.T.
	4X011	9 + 9	6.66	
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	4X014	18 + 18	3.33	
	4X015	22 + 22	2.72	
	4X016	25 + 25	2.40	
	4X017	30 + 30	2.00	
	4X018	35 + 35	1.71	
	4X028	110	1.09	
	4X029	220	0.54	
	4X030	240	0.50	

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	5X012	12 + 12	6.66	
	5X013	15 + 15	5.33	
	5X014	18 + 18	4.44	
	5X015	22 + 22	3.63	
	5X016	25 + 25	3.20	
	5X017	30 + 30	2.66	
	5X018	35 + 35	2.28	
	5X026	40 + 40	2.00	
	5X028	110	1.45	
	5X029	220	0.72	
	5X030	240	0.66	
225va 110 × 45mm 2.2 Kg regulation 7%	6X012	12 + 12	9.38	£10.06 + £1.73 + £1.77
	6X013	15 + 15	7.50	
	6X014	18 + 18	6.25	
	6X015	22 + 22	5.11	
	6X016	25 + 25	4.50	
	6X017	30 + 30	3.75	
	6X018	35 + 35	3.21	
	6X026	40 + 40	2.81	
	6X025	45 + 45	2.50	
	6X028	110	2.04	
	6X029	220	1.02	
	6X030	240	0.93	
300va 110 × 50mm 2.6 Kg regulation 6%	7X014	18 + 18	8.38	£11.66 + £1.73 + £2.01
	7X015	22 + 22	6.82	
	7X016	25 + 25	6.00	
	7X017	30 + 30	5.00	
	7X018	35 + 35	4.28	
	7X026	40 + 40	3.75	
	7X025	45 + 45	3.33	
	7X033	50 + 50	3.00	
	7X028	110	2.72	
	7X029	220	1.36	
	7X030	240	1.25	
500va 140 × 60mm 4 Kg regulation 4%	8X017	30 + 30	8.33	£15.53 + £2.05 + £2.64
	8X018	35 + 35	7.14	
	8X026	40 + 40	6.25	
	8X025	45 + 45	5.55	
	8X033	50 + 50	5.00	
	8X042	55 + 55	4.54	
	8X028	110	4.54	
	8X029	220	2.27	
	8X030	240	2.08	

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625va 140 × 75mm 5.0 Kg. regulation 4%	9X017	30 + 30	10.41	£21.54 + £2.20 + £3.56
	9X018	35 + 35	8.92	
	9X026	40 + 40	7.81	
	9X025	45 + 45	6.94	
	9X033	50 + 50	6.25	
	9X042	55 + 55	5.68	
	9X028	110	5.68	
	9X029	220	2.84	
	9X030	240	2.60	

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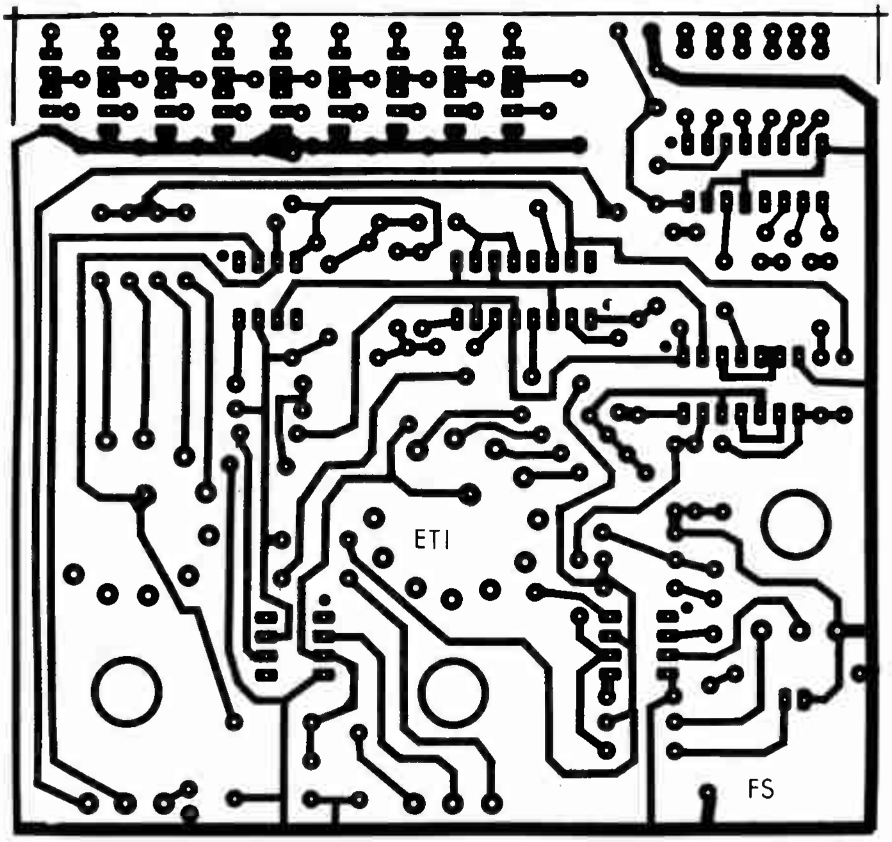
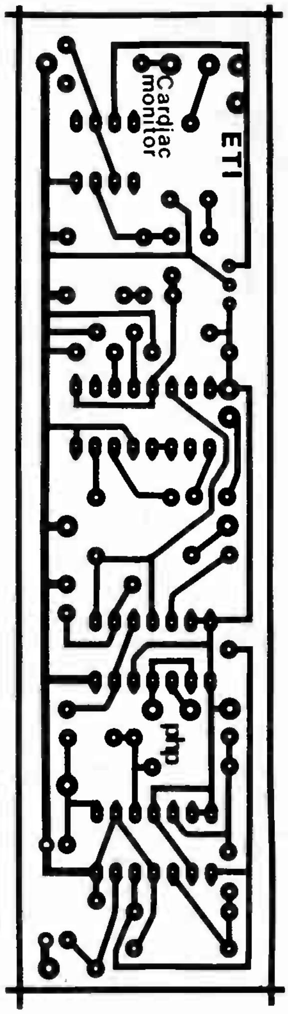
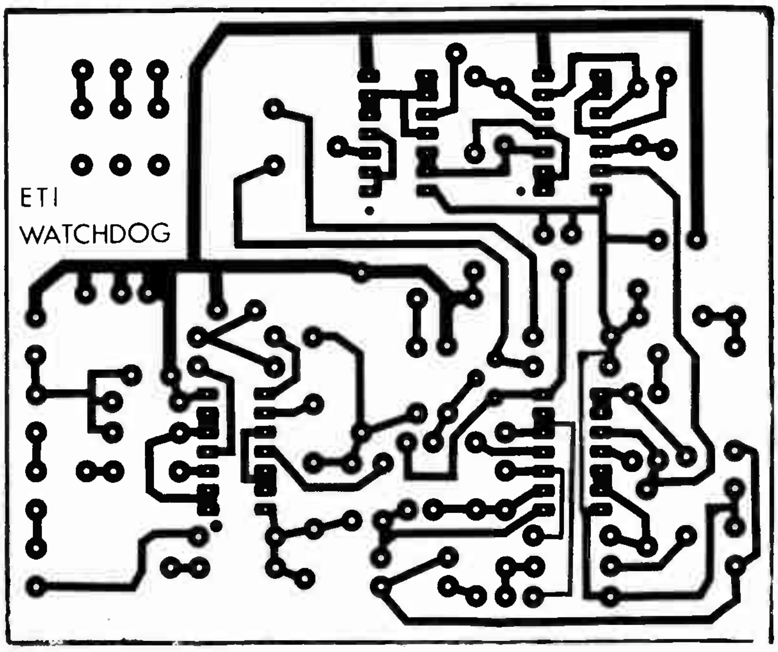


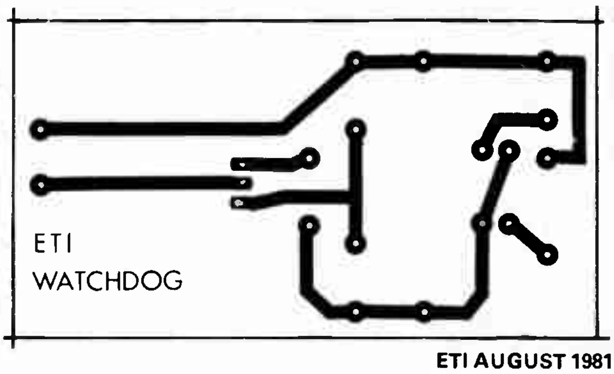
Above: the foil pattern for the Flash Sequencer.

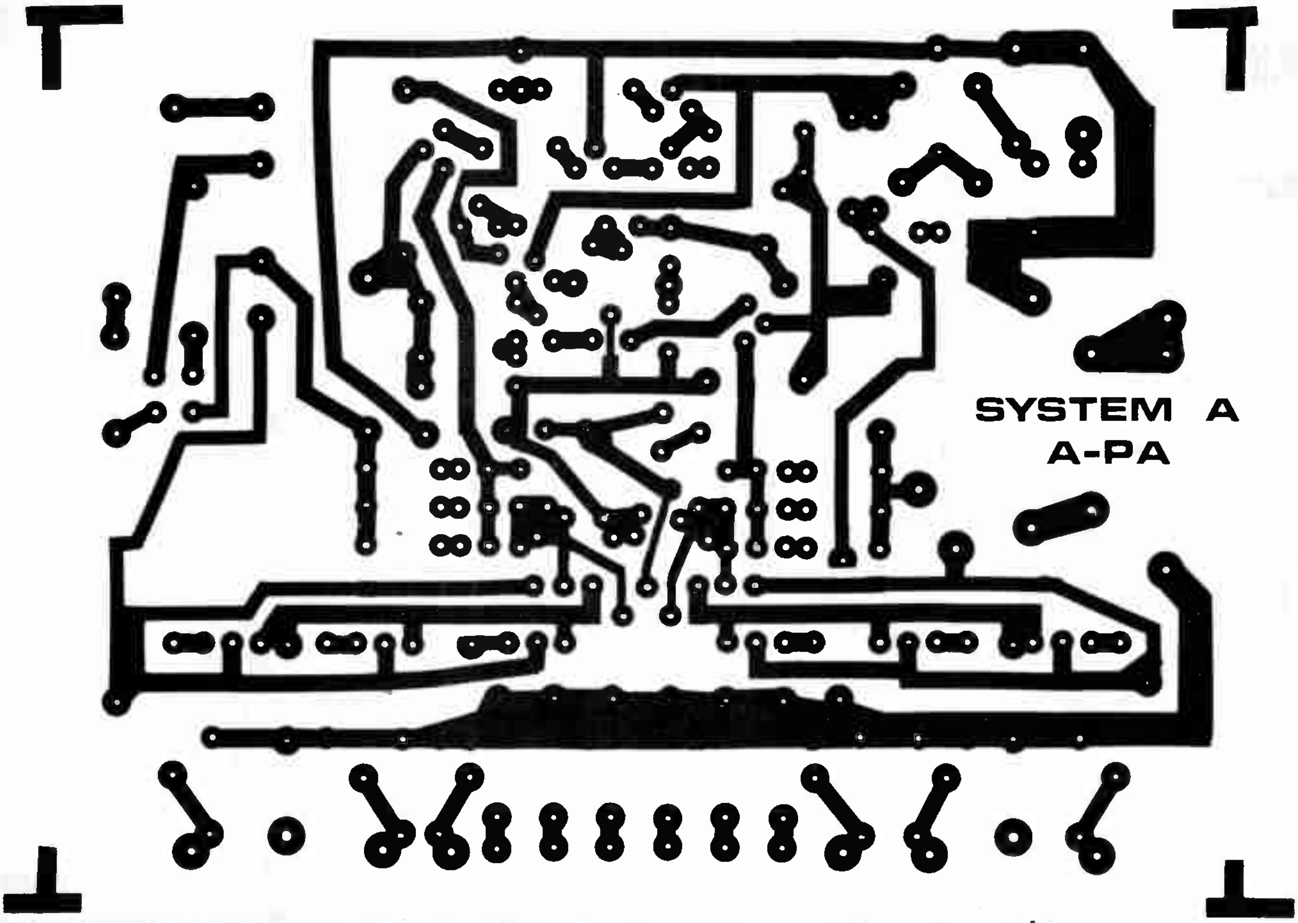


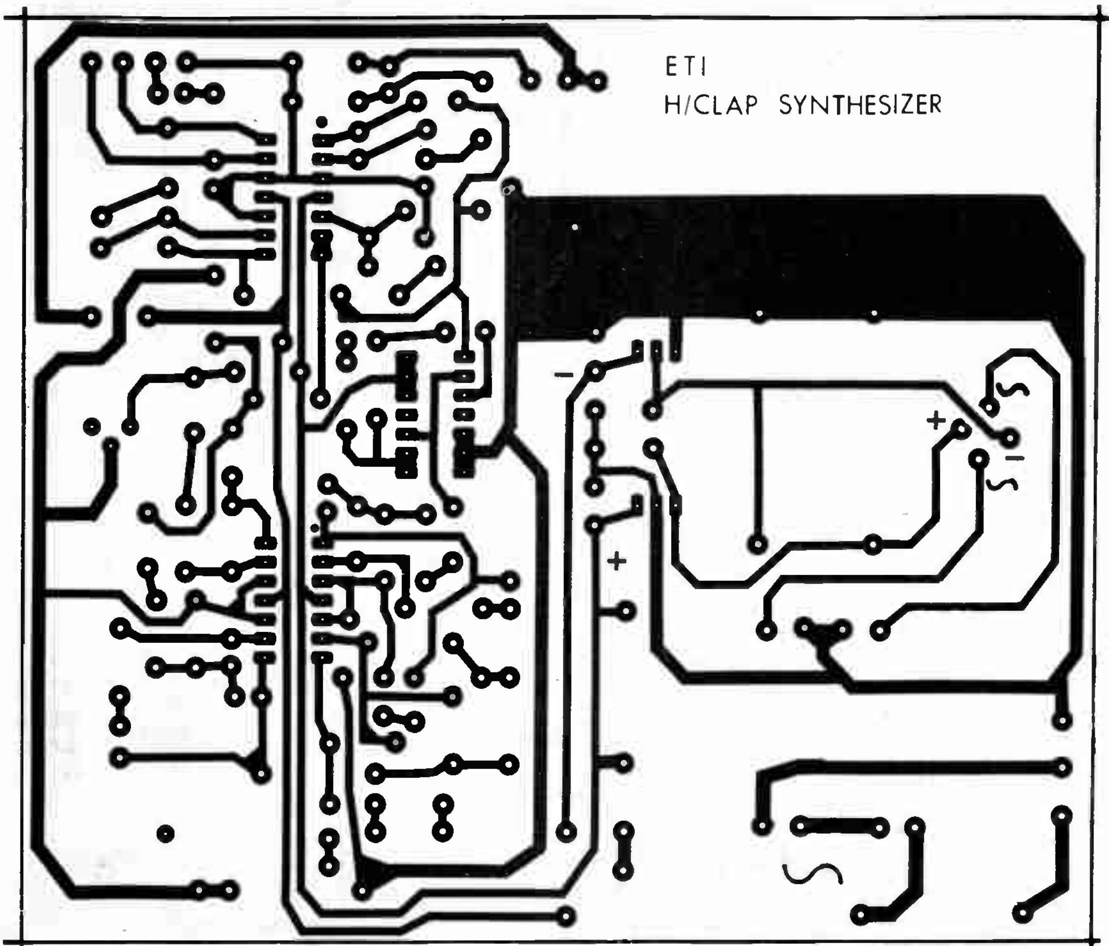
Above: the Heartbeat Monitor board.



Left and below: the PCBs for the Watchdog main unit and the Ni-Cd charger.







Above: the System A power amplifier foil pattern.

Left: the Hand-clap Synthesiser PCB.

The DJ90 PCBs are too large to fit in the magazine; an SAE to us will secure a photocopy. Commercial companies should note that these, and the System A boards, are copyright and may not be reproduced without permission.

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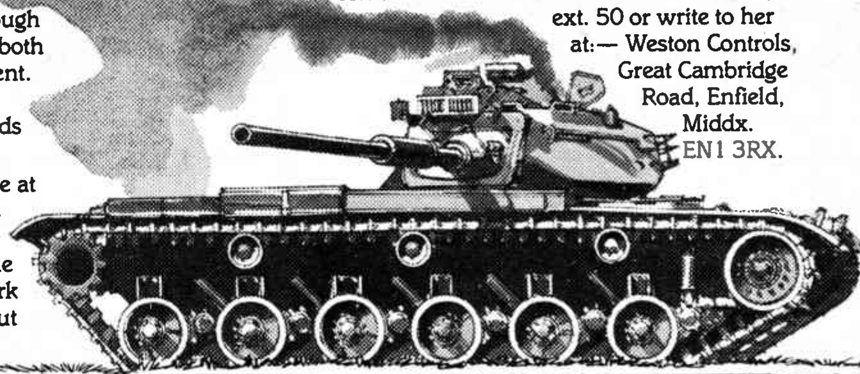

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